water temperatures ranged from 5.8 to 20 degrees Celsius (42.4 to 68 degrees Fahrenheit) while the temperature 10 meters (30 feet) below the surface ranged between 5 and 7 degrees Celsius (41 and 45 degrees Fahrenheit) (Quinault Fisheries Division 1991). Summer water temperatures in the lower river are warm and can exceed 16 degrees Celsius (61 degrees Fahrenheit) for several days between late June and the end of September. In contrast, temperatures in the tributaries appear to be cooler, with daily averages of 8.9 to 13.1 degrees Celsius (48 to 56 degrees Fahrenheit) measured in Cook and Boulder Creeks during the summer months.

Approximately 51 percent of the watershed lies within Olympic National Park, including all of the upper drainage and headwaters. The Quinault Indian Nation owns 32 percent of the basin, comprising most of the area downstream of Lake Quinault (Quinault Indian Nation and U.S. Forest Service 1999). The U.S. Forest Service manages 13 percent of the watershed, including the eastern part of the Cook Creek watershed and the southwest half of the Lake Quinault watershed between Quinault Ridge and the upper Quinault River. Private landholdings comprise only 4 percent of the lands in the basin, and Rayonier Timberlands Company is the largest private landholder, managing 5,677 hectares (14,030 acres) in the Cook Creek area (Quinault Indian Nation and U.S. Forest Service 1999).

Queets Core Area (Grays Harbor and Jefferson Counties) (Figure 5). The Queets core area includes all streams flowing in the Queets River basin and the estuary. The Queets River originates as meltwaters from glaciers on Mount Queets and from permanent snowfields on Bear Pass and Mount Barnes. The Queets River flows 82.7 kilometers (51.4 miles) from its headwaters to the Pacific Ocean. Tributaries drain from precipitous ridges, but the mainstem and lower tributaries are characterized by the wide, moderate gradient valleys and braided channels typical of a glacial river system. The Clearwater River is a major tributary to the Queets River that flows 59.1 kilometers (36.7 miles) from its headwaters to the confluence with the Queets River at river mile 6.8 and contains 285.2 kilometers (177.2 miles) of tributary streams. The Queets River contains 518 kilometers (321.9 miles) of tributaries in addition to the Clearwater River drainage. Other major tributaries of the Queets River include the Salmon and Sams Rivers and Matheny and Tshletshy Creeks.

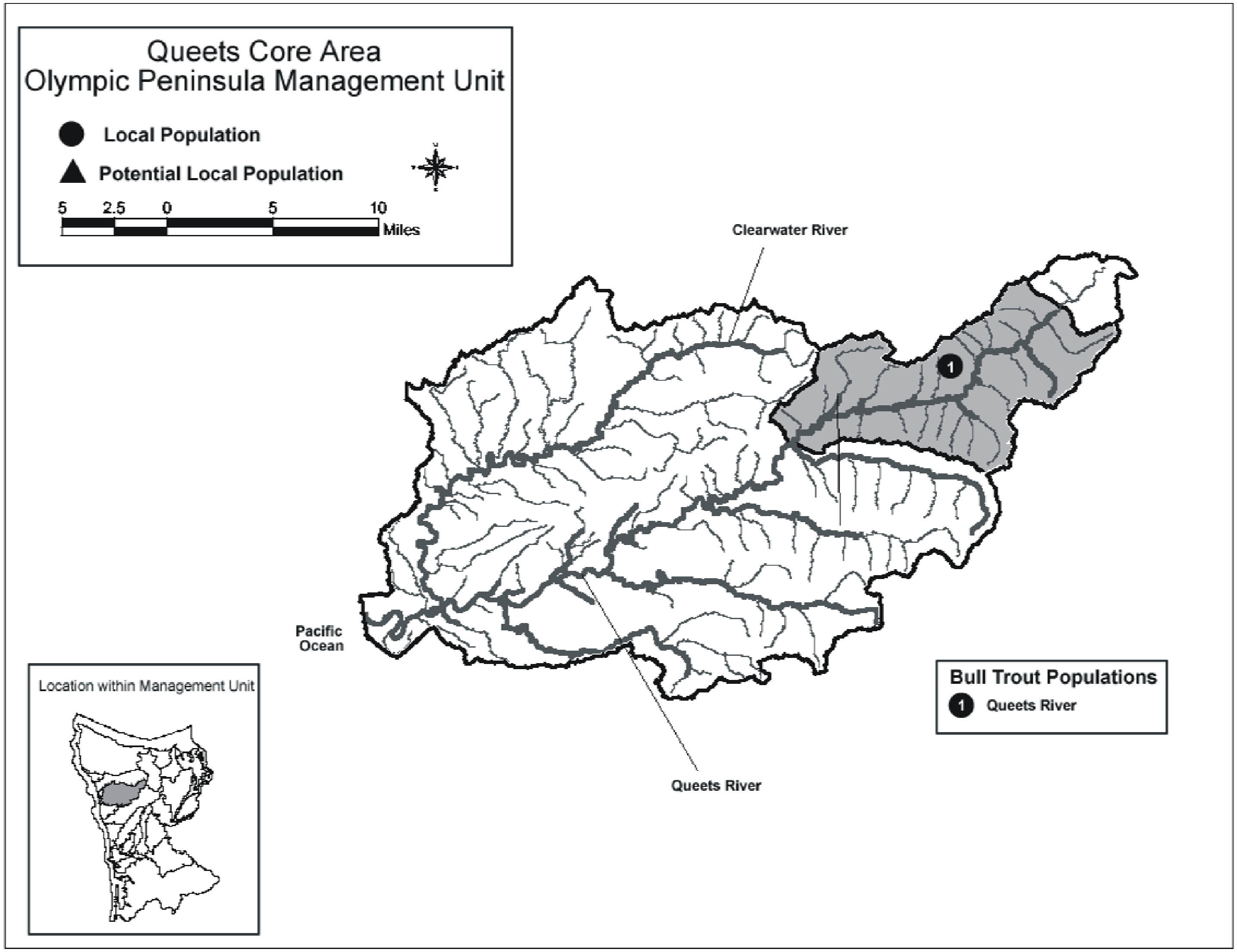

Figure 5. Queets core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

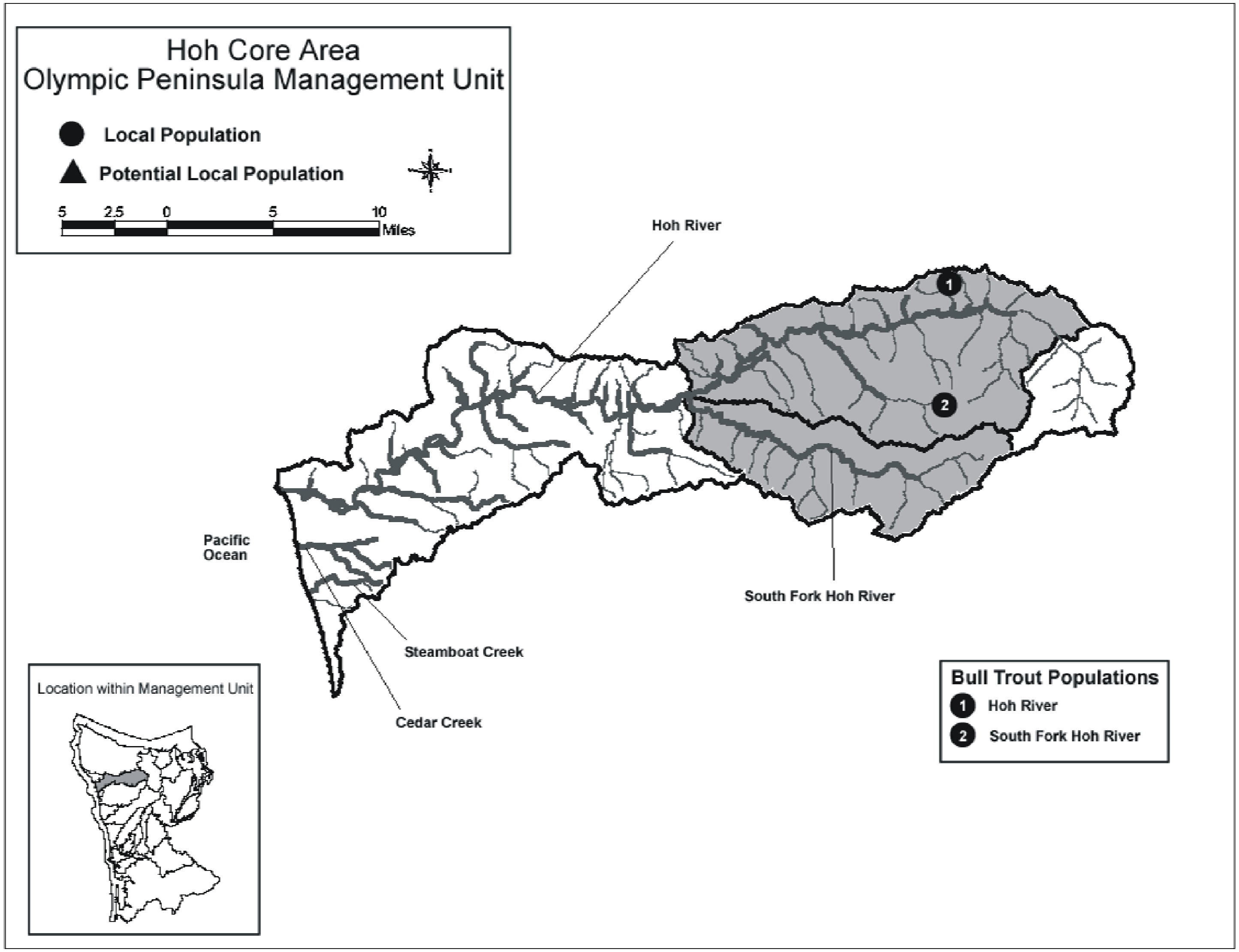

Figure 6. Hoh core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

The Queets River watershed has an average annual precipitation of 305 to 508 centimeters (120 to 200 inches). The wettest season is between November and April and winter storms can deliver 25 centimeters (10 inches) of rain over a 24-hour period. Elevations below 500 meters (1,640 feet) are generally rainfall dominated, while mixed rain-on-snow events are common between 500 and 1,000 meters (1,640 and 3,280 feet). Winter precipitation falls mainly in the form of snow above 1,000 meters (3,280 feet) (WDNR 1997).

The Queets mainstem is contained entirely within a narrow corridor of Olympic National Park upstream of river mile 8.1. The short section between the Olympic National Park boundary and the Pacific Ocean flows through the Quinault Indian Reservation. Except for short terminal sections entering the Queets River mainstem, the upstream areas of tributary streams below river mile 24.1 are outside of the Olympic National Park boundary. The Clearwater River flows primarily through State and private lands. The Salmon River is contained mostly within the boundaries of the Quinault Indian Reservation. Matheny Creek and Sams River flow mainly through the Olympic National Forest.

Hoh Core Area (Jefferson and Clallam Counties) (Figure 6). The Hoh River is a large, glacially influenced river with an extensive, active flood plain. It flows westward from its headwaters in Olympic National Park at 1,216 meters (3,989 feet) elevation to its confluence with the Pacific Ocean. The headwaters of the Hoh drain the Baily Range and the north slope of Mount Olympus. The Hoh River flows 90.3 kilometers (56.1 miles) from its headwaters to the Pacific Ocean and contains 441.9 kilometers (274.6 miles) of tributaries (Phinney and Bucknell 1975). Its major tributaries originate from numerous alpine glaciers and snowfields in the upper portions of the watershed. Numerous spring-fed terrace tributaries also feed the Hoh River and its tributaries. A series of cascades in the upper Hoh River located at river mile 48.5 (upstream of the confluence with Glacier Creek) may be a barrier to upstream passage of fish (Phinney and Bucknell 1975). The Hoh core area includes all streams flowing in the Hoh River basin.

The South Fork Hoh joins the Hoh River at river mile 30 and descends in elevation from 1,475 meters (4,839 feet) to 128 meters (420 feet) at its confluence with the Hoh River. A possible barrier to upstream fish passage in the South Fork Hoh exists upstream of river mile 14 (Phinney and Bucknell 1975).

The annual precipitation in the headwaters of the Hoh River is estimated at 610 centimeters (240 inches), the highest known rainfall in the lower 48 states (Schreiner *et al.*1996). River discharge is strongly influenced by this rainfall in winter, and by glacial melt and snowmelt in the spring. Most tributary streams located outside Olympic National Park are predominately influenced by rainfall.

The upper section of the Hoh watershed (approximately 65 percent of the watershed) lies entirely within Olympic National Park. The lower reaches flow through State, Tribal, and private lands. The area of the Hoh River outside of the park extends from river mile 1.5 to river mile 30.

Elwha Core Area (Clallam and Jefferson Counties) (Figure 7). The Elwha River, located on the north side of the Olympic Peninsula, is the largest river draining into the Strait of Juan de Fuca. Historically, the Elwha River may have been the most productive salmon river within the Olympic Peninsula (WSCC 2000a). The Elwha River originates on the south and east sides of Mount Olympus in Olympic National Park, flowing south then turning northward to the Strait of Juan De Fuca. Most of the tributary headwaters originate at about 1,219 meters (4,000 foot) elevation. The Elwha River drains 84,000 hectares (321 square miles or 208,000 acres). Despite the rugged headwater terrain, the river’s gradient is mostly moderate for much of its length. The mainstem is approximately 72 kilometers (45 miles) in length with 160 kilometers (100 miles) of tributary streams. The Elwha core area includes the Elwha River, its tributaries, Lake Mills and Lake Aldwell, and the estuary.

The construction of two dams (Elwha Dam in 1914 and Glines Canyon Dam in 1927) divided the Elwha River into three relatively isolated sections: the Lower Elwha River (downstream from the Elwha Dam), the middle Elwha River (between Elwha Dam and Glines Canyon Dam), and the upper Elwha (upstream of Glines Canyon Dam). There is no upstream passage at either dam and it is believed that there is little habitat downstream from the dams suitable for bull trout spawning and incubation. Elevated stream temperatures in both the lower

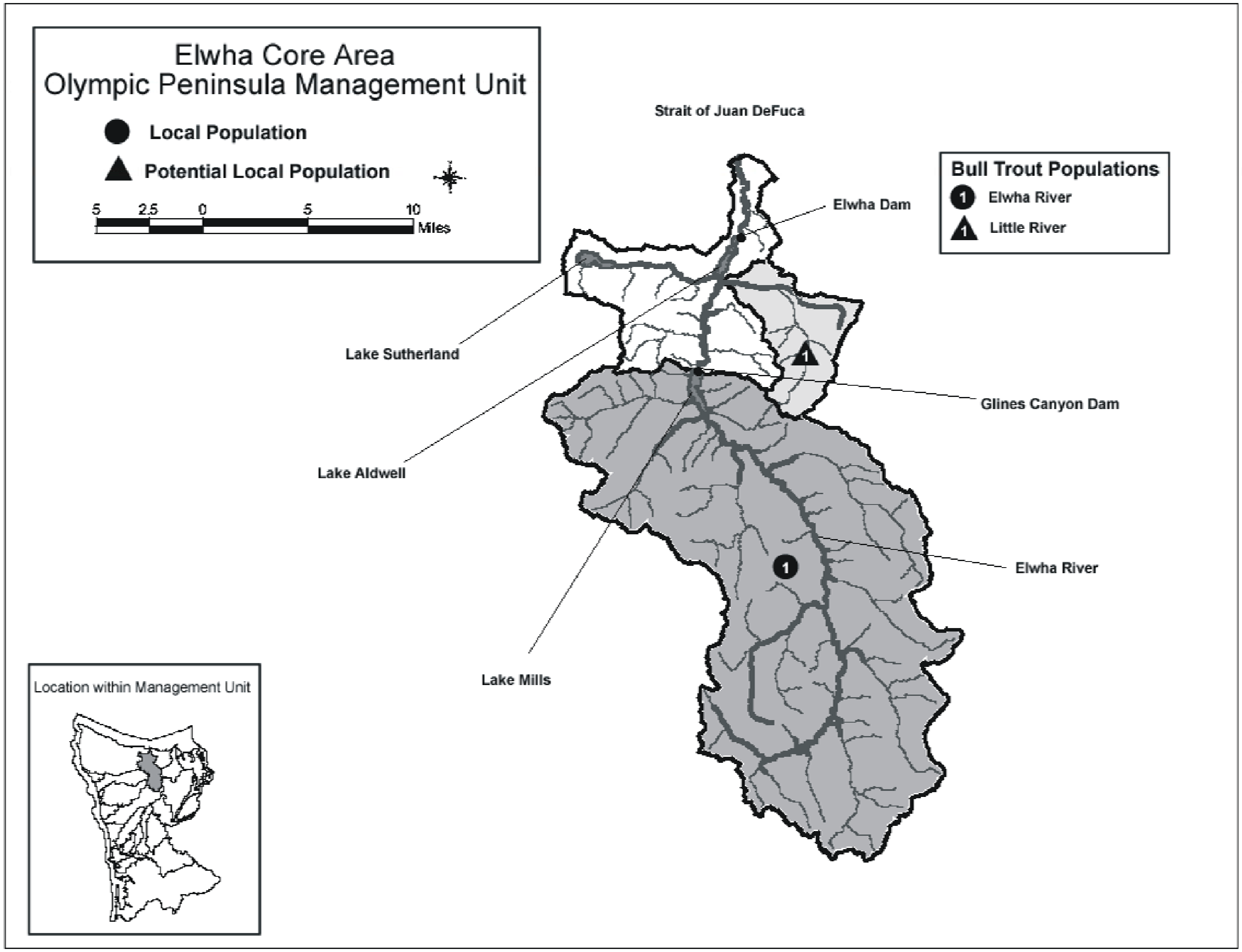

Figure 7. Elwha core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

and middle reaches of the Elwha River likely limit reproducing populations of bull trout (McHenry 2002).

Eighty-three percent of the area drained by the Elwha River is located within Olympic National Park. The lower reaches flow through State, Tribal, U.S. Forest Service, and private lands.

Dungeness Core Area (Clallam and Jefferson Counties) (Figure 8). The Dungeness core area includes the Dungeness River, its primary tributary the Gray Wolf River, associated tributaries, and the estuary. The Dungeness River, located in the northeastern corner of the Olympic Peninsula, drains into the Strait of Juan de Fuca. Mount Constance, the highest point in the watershed, forms the southern boundary. The Dungeness River flows 51.3 kilometers (31.9 miles) from its headwaters to the Strait of Juan de Fuca and contains 361.3 kilometers (224.5 miles) of tributaries (Phinney and Bucknell 1975). Major subdrainages within the watershed include Meadowbrook, Matriotti, Hurd, Bear, Canyon, and Gray Wolf subbasins[†].

The primarily sedimentary geology in the Dungeness River watershed has an overlay of lake deposits on top of glacial and alluvial moraines[†] that is largely responsible for the inherent instability of the upper watershed (WSCC 2000a).This instability of the upper watershed has provided the upper Dungeness River with a significant load of coarse and fine sediments. As these sediments were transported out of the upper watershed, they were deposited in a large alluvial fan[†]. This alluvial fan gives the “Dungeness Valley” a unique topography and contributes to stream instability (WSCC 2000a). As the river deposited sediments in the lower valley, channel migration occurred across the alluvial fan. The Dungeness River historically flowed over, down, and throughout what are currently tributary streams. Many of these streams have been affected by irrigation ditches, river dikes, and channelization[†] in the fertile former floodplain[†] of the Dungeness River.

Federal and State agencies, including the National Park Service, U.S. Forest Service, and Washington Department of Natural Resources, manage more than 50 percent of the watershed. Much of the private land is in large holdings

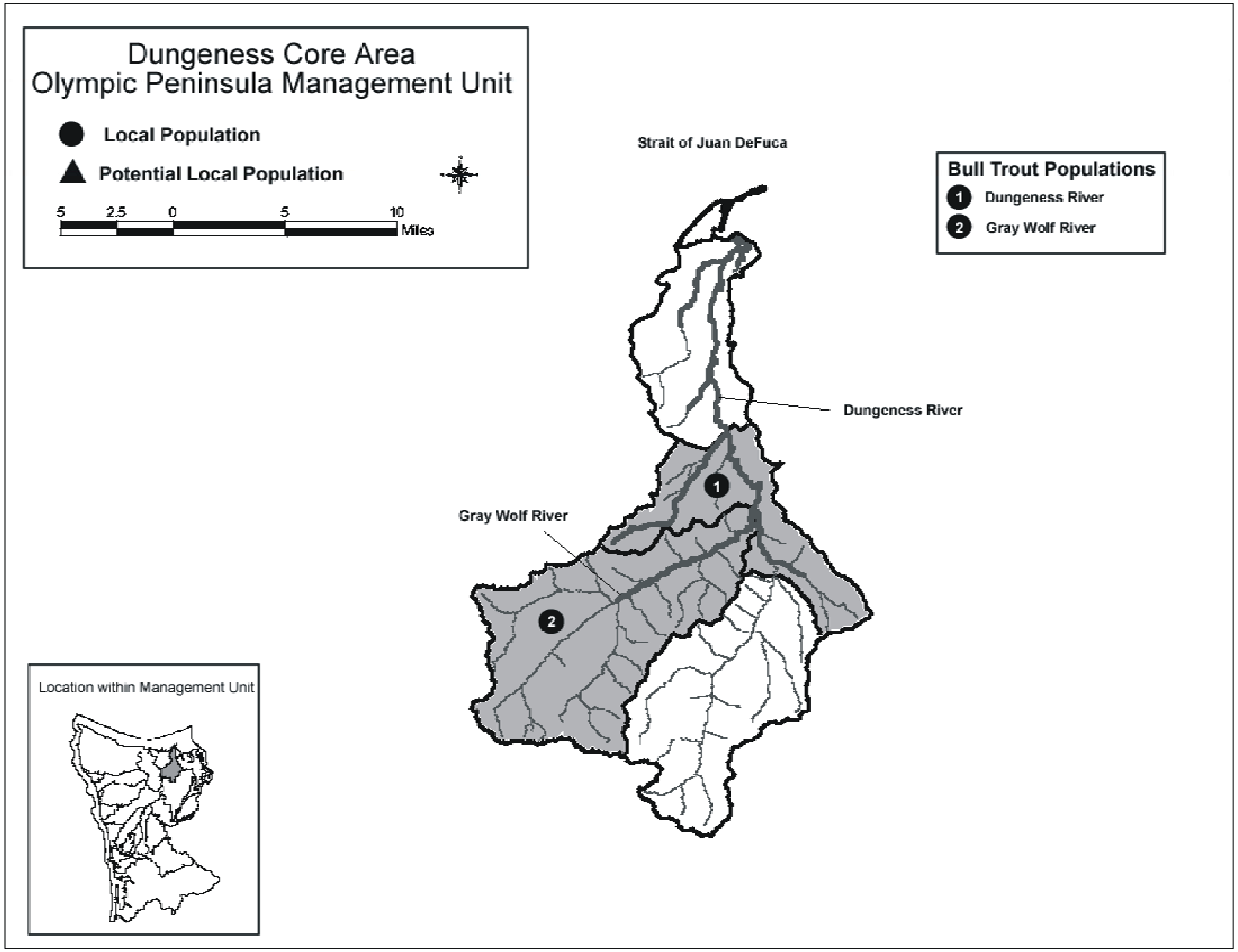

Figure 8. Dungeness core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

for timber production. In recent years, many ownerships have changed and forest lands are being converted to residential and other uses. Land uses include pasture, hayland and cropland on both commercial and small farms, residential development scattered throughout the lower watershed, private and public forest land in the upper watershed, as well as a large portion of Olympic National Park in the headwaters areas.

DISTRIBUTION AND ABUNDANCE

Status of Bull Trout at the Time of Listing

On November 1, 1999, we issued a final rule listing the Coastal-Puget Sound population of bull trout as a threatened species (64 FR 58910). In the final listing rule, we identified 18 subpopulations[†] occurring in 9 river basins within the area now delineated as the Olympic Peninsula Management Unit[2]. We considered habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, harvest, and introduced nonnative species as the greatest threats to bull trout in this area. Although subpopulations were an appropriate unit upon which to base the 1999 listing decision, the recovery plan has revised the biological terminology to better reflect both our current understanding of bull trout life history and conservation biology theory. Therefore, subpopulation terms will not be used in this chapter. Instead, recovery of the bull trout will be based on bull trout “core areas” as described above in Part I, Recovery Plan Terminology and Structure.

Current Distribution and Abundance

Bull Trout and Dolly Varden. Bull trout and Dolly Varden occur together only within the area of the Coastal-Puget Sound Distinct Population Segment and in British Columbia, Canada. Although these two species of native char were previously considered a single species, the bull trout and the Dolly Varden are now formally recognized as two separate species (Cavender 1978;

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[2]Due to the lack of sufficient genetic analysis for most subpopulations, bull trout and Dolly Varden were not identified as distinct subpopulations at the time of listing. The term “native char” was used to describe populations that could include both Dolly Varden and bull trout.

Robins *et al.* 1980; Bond 1992). Currently, genetic analyses can distinguish between the two species (Crane *et al.* 1994; Baxter *et al.* 1997; Leary and Allendorf 1997). In the Olympic Peninsula Management Unit, Dolly Varden have been confirmed in the Dungeness and Quinault core areas (Leary and Allendorf 1997; Young, *in litt.* 2001; Spruell and Maxwell 2002). Dolly Varden have also been confirmed in the Soleduck River above an anadromous barrier. No bull trout have been identified in the Soleduck River and this area is not identified as a core area.

In the Coastal-Puget Sound Distinct Population Segment, Dolly Varden tend to be distributed as isolated tributary populations above natural anadromous barriers (as in the Dungeness core area), while bull trout are distributed below these barriers (WDFW 1998; Spruell and Maxwell 2002). An exception to this is found in the Quinault core area where Dolly Varden and bull trout occur within the same area in the upper Quinault River and are not isolated above a barrier (Leary and Allendorf 1997). In all other core areas within the management unit, all char sampled have been identified genetically as bull trout. Based on this information, we have assumed that all native char observed in accessible anadromous reaches other than in the Quinault core area are bull trout.

Bull Trout Distribution. In portions of the Olympic Peninsula Management Unit, bull trout may not currently occupy habitat that is believed to have supported reproducing bull trout historically. For example, credible anecdotal accounts (J. Webster, U. S. Forest Service, pers. comm. 2002; Keizer 1990; Donald 1991) provide historical documentation of large fluvial bull trout in the Satsop River, a tributary to the Chehalis River. Recent surveys of the Satsop River did not detect bull trout in tributaries where they were previously documented (L. Ogg, U.S. Forest Service, pers. comm. 2003a). Additional bull trout populations may be fragmented and isolated in headwater locations due to natural or manmade barriers.

Currently, bull trout are distributed throughout most of the large rivers and associated tributary systems within the Olympic Peninsula Management Unit (WDFW 1998). At present there are 10 local populations distributed among the 6 identified core areas (Skokomish, Dungeness, Elwha, Hoh, Queets, Quinault). The recovery team also identified two potential local populations†: Brown Creek in the Skokomish core area and Little River in the Elwha core area. Both Brown Creek and Little River are connected to bull trout occupied habitat, have suitable water temperatures, and would provide additional local populations in core areas that have two or fewer identified local populations (McHenry, *in litt*. 2003; L. Ogg, pers. comm. 2003c).

Bull trout exhibit multiple life history strategies throughout their range (Rieman and McIntyre 1993). Bull trout in the Olympic Peninsula Management Unit demonstrate all known migratory life history patterns (*i.e.*, anadromous, adfluvial, and fluvial) for this species, and nonmigratory, or resident, life history patterns may also be present, although this has not yet been confirmed. There are two naturally occurring adfluvial bull trout populations within the management unit; one is associated with Lake Cushman in the upper North Fork Skokomish drainage, and the other is associated with Lake Quinault in the Quinault River drainage.

Within the range of bull trout in the coterminous United States, anadromy, or technically “amphidromy,” is unique to the Coastal-Puget Sound Distinct Population Segment. Unlike strict anadromy, amphidromous individuals often return seasonally to freshwater as subadults, sometimes for several years, before returning to spawn (Wilson 1997). Subadult bull trout in the Coastal-Puget Sound Distinct Population Segment can move into marine waters to forage or migrate and return to freshwater to take advantage of seasonal forage provided by salmonids eggs, smolts, or juveniles.

Bull trout in this population segment also move through marine waters to access independent tributaries (tributaries that connect directly to marine waters) to forage or, potentially, to take refuge from high flows in their core areas (Brenkman and Corbett, *in litt.* 2003a,b). Independent tributaries used by bull trout on the Olympic Peninsula are not believed to support spawning populations of bull trout and are only accessible to bull trout by swimming through marine waters from core areas. These independent tributaries include Bell, Morse, Ennis, and Siebert Creeks in the Strait of Juan de Fuca; Goodman, Cedar, Kalaloch, Steamboat, Mosquito, and Joe Creeks, and the Raft, Moclips, and Copalis Rivers on the coast; and Wishkah and Humptulips Rivers in Grays Harbor. Although there are anecdotal and historical observations of bull trout in Hood Canal tributaries (e.g. Hamma Hamma, Dosewallips, Duckabush Rivers), there are no current records of bull trout in independent tributaries to Hood Canal(U.S. Commission on Fish and Fisheries, *in litt.* 1913; McLeod 1944; P. Hilgert, R2 Resources, pers. comm. 2000). Independent tributaries documented as being used seasonally by bull trout on the Olympic Peninsula are also productive salmon streams (Phinney and Bucknell 1975).

Migratory forms appear to develop when habitat conditions allow movement between spawning and rearing streams and larger rivers and lakes and, for Olympic Peninsula bull trout, marine and estuarine waters where foraging opportunities are enhanced (Kraemer 1994; Frissell 1999). Benefits to migratory bull trout include greater growth in the more productive waters of larger streams, lakes, estuaries, and nearshore marine areas; greater fecundity resulting in increased reproductive potential; and dispersal of the population across space and time. In the Skagit River system, a benefit for anadromous bull trout with access to more productive marine forage is reflected in the size of these fish at maturity. Fluvial and anadromous bull trout in the Skagit River system both reach sexual maturity at around 4 years of age; however, the anadromous fish were almost 100 millimeters larger than their fluvial counterparts at that age (Kraemer, *in litt.* 2003).

Macroinvertebrates are a major food item for bull trout fry before they shift to a piscivorous (fish-eating) diet. In fresh water, important forage includes loose macroinvertebrates, salmon eggs, salmon fry and smolts, sculpin, whitefish, and other small fish.

Anadromous and fluvial life history forms typically have widely distributed foraging, migration, and overwintering habitat. Migratory bull trout use nonnatal (habitat outside of their spawning and early rearing habitat) watersheds to forage, migrate, and overwinter (Brenkman and Corbett, *in litt.* 2003a,b).   Larger juvenile and subadult bull trout can migrate throughout a core area looking for feeding opportunities, or they can move through marine areas to independent tributaries. Because bull trout forage on salmon fry and eggs, the recovery team identified reaches accessible to salmon both in streams within core areas and in independent tributaries outside of core areas as freshwater foraging habitat for bull trout (Phinney and Bucknell 1975). The recovery team identified accessible habitat occupied by salmonids, where these fish can provide a forage base for bull trout, as essential and biologically important for bull trout (Olympic Peninsula Recovery Team, *in litt.* 2003b).

Subadult and adult bull trout in the Coastal-Puget Sound Distinct Population Segment also forage in marine waters where the principal forage include surf smelt and other small schooling fish (*e.g.,* sandlance, herring) (Kraemer 1994, Brenkman and Corbett, *in litt.* 2003a). Although foraging bull trout are likely to concentrate in forage fish spawning areas, they can be found throughout accessible estuarine and nearshore habitats. Maintaining these forage species and marine foraging areas is essential and biologically important for maintaining the anadromous life form of bull trout. The conservation needs for bull trout in this management unit extend into the marine waters and many independent tributary drainages that flow to marine waters.

Although multiple age classes of bull trout have been observed in all core areas, spawning has not yet been documented in the Quinault and Elwha core areas. Sampling for migratory bull trout is especially difficult due to their wide-ranging seasonal movements. Radio telemetry has been a useful tool for providing new and important information about spawning sites and movement, but it is limited by its ability to document fish movements within a narrow range of detection. For example, when bull trout from the Hoh River move into an adjacent river, aerial flights along the coast will detect those individuals that are in fresh water and near the mouth of the river. If the fish have moved further upstream, flights must be made up the river to detect those individuals. If the fish are in marine waters, the signal will not be detected.

Current data on distribution and abundance in the Olympic Peninsula is limited and has been collected by a variety of methods. Sources of data include historical reports, incidental bull trout counts obtained during other fish surveys, salmon smolt and adult traps, creel survey data, redd counts, adult counts, radio telemetry surveys, and beach seining. There are significant differences in spawning survey protocols (*e.g.,* different survey locations, different survey distances, different survey times, and the number of subsequent surveys per site). These survey protocol differences, coupled with extremely difficult access, concurrent coho salmon spawning, very high or very low flows, and poor visibility during glacial melt, have made it difficult to locate spawning areas. An increased and sustained survey effort has been identified as a high priority by the recovery team and would likely identify additional local populations in most core areas.

The Washington Department of Ecology analyzed all spawning data for bull trout west of the Cascade Mountains to determine the elevation above which spawning would most likely occur (WDOE 2002). The recovery team used this analysis to help identify local populations where no, or very little, spawning site information was available. All spawning sites occurred above 150 meters (500 feet) in elevation. Table 3 lists the streams where spawning is known to occur in the Olympic Peninsula Management Unit.

There is currently insufficient data to confidently estimate bull trout abundance for many core areas and for the entire management unit. The Skokomish core area is the only core area that has been monitored through redd counts and adult counts at a level where estimates can be made at the local population and core area levels.

Table 3. Known spawning streams in the Olympic Peninsula Management Unit (indentation indicates a tributary of the previous nonindented stream); "rm" = river mile.

CORE AREA	KNOWN SPAWNING STREAMS

Skokomish River	South Fork Skokomish River (rm 19 to rm 24)
	    Church Creek (rm 0 to rm 0.5)
	North Fork Skokomish River (above Cushman Dam)
	    Elk Creek
	    Slate Creek

Hoh River	Hoh River (rm 43 to rm 48)
	    "OGS" Creek (near mouth)
	    Cougar Creek (lower portion)
	South Fork Hoh River (rm 9 to rm 15)

Queets River	Queets River (rm 45 to rm 48)
Dungeness River	Gray Wolf River (rm 2 to rm 4)

Skokomish Core Area. Adfluvial, fluvial, and possibly anadromous and resident bull trout inhabit this core area. There are two local populations identified in this core area: the North Fork Skokomish River local population and the South Fork Skokomish River local population. Brown Creek, a tributary to the South Fork Skokomish River, has been identified as a potential local population.

The North Fork Skokomish River local population includes bull trout that inhabit Lake Cushman in Olympic National Forest and the river upstream from the reservoir in Olympic National Park. Results from genetic analyses of four fin clips collected in the North Fork Skokomish River confirmed the presence of bull trout (Brenkman 1998). Adfluvial bull trout inhabit the reservoir at Lake Cushman, the North Fork Skokomish River, and Elk and Slate Creeks (Brenkman 1998). Bull trout have also been documented upstream from Lake Cushman to the confluence of Four Stream in Olympic National Park (river mile 27.96 to river mile 31.50). There is no evidence of resident bull trout in nine tributaries to the upper North Fork Skokomish River despite extensive electrofishing and day snorkel surveys (Brenkman 1998). A series of cascades (Staircase Rapids) above Lake Cushman may prevent upstream passage of some fish species. The Washington Department of Fish and Wildlife (1998) maintains that Staircase Rapids is a barrier to upstream migration of bull trout. However, Olympic National Park biologists observed adult bull trout estimated up to 63.5 centimeters (25 inches) in length upstream of Staircase Rapids. Olympic National Park personnel believe these large fish originated from Lake Cushman. Tagging or other studies are needed to determine whether bull trout with a fluvial or resident life history form exist in the river, and if so, whether these fish are reproductively isolated from adfluvial bull trout that migrate from the reservoir (Brenkman, *in litt.* 2003b).

Historical accounts indicate the presence of native char in Lake Cushman prior to its impoundment (Harza Northwest, Inc., *in litt.* 1991). Although specific data are lacking on whether bull trout were able to ascend the series of cascades (Little and Big Falls) prior to the construction of Cushman Dams 1 and 2, historical records indicate that Chinook salmon and steelhead migrated upstream past the two falls to reach their spawning habitat (Stetson, *in litt.* 1925; Mayhall, *in litt.* 1926; Pollock, *in litt.* 1929; Moore, *in litt.* 1948). Since the falls downstream of the Cushman Dams are described as being a series of cascades, it is likely that bull trout were also able to pass these turbulent areas. Surveys for bull trout have not been conducted in Lake Kokanee (formed by Cushman Dam 2) or its tributaries, and little is known about bull trout use of the North Fork Skokomish River downstream of the lake.

Available habitat for bull trout spawning in the North Fork Skokomish River upstream from Lake Cushman appears to be limited. Spawning has been observed from river mile 28 to a point upstream near the confluence of Four Stream (Brenkman 1998), although most spawning occurs downstream from Staircase Rapids. Adult adfluvial bull trout typically enter the North Fork Skokomish River in October, although some fish enter as early as May. Increased river discharge and decreased water temperature appear to influence timing of migration; spawning may occur as late as early December (Brenkman *et al*. 2001).

The maximum estimated lengths of adult bull trout upstream and downstream of Staircase Rapids were 635 millimeters (25 inches) and 813 millimeters (32 inches), respectively. The ages of bull trout from 440 millimeters (17 inches) to 850 millimeters (33 inches) in length ranged from 3 to 16 years based on analysis of otoliths[†] (structures in the fish ear) from fish collected in 1968 and 1969 (WDFW 1998).

Observations of young-of-year and juvenile bull trout are limited despite extensive day snorkel surveys throughout 5.6 kilometers (3.5 miles) of the North Fork Skokomish River (Brenkman 1998). Low numbers of young-of-year and juvenile bull trout were found in the river and Elk and Slate Creeks during the summer months. The lower portion of Slate Creek often goes dry during summer months. Elk and Slate Creeks likely do not support multiple year classes of juvenile bull trout on an annual basis, based on extreme low or no flow conditions during summer months. Based on the professional judgement and experience of members of the recovery team, Elk and Slate Creeks are considered part of the North Fork Skokomish River local population (Olympic Peninsula Recovery Team, *in litt.* 2003a).

Snorkel and walking surveys of adult bull trout have been conducted annually in the North Fork Skokomish River above Lake Cushman since 1973, which likely represents the longest term bull trout data set in Washington (Figure 9; Brenkman, *in litt.* 2003a). Adult counts declined from 391 in 1973 to 81 in 1979. No surveys were conducted from 1980 through 1984; however, harvest for bull trout in the North Fork Skokomish River above Lake Cushman was eliminated in 1982 and in Lake Cushman in 1986 (WDFW 1998). After elimination of harvest, the number of adult bull trout in the North Fork Skokomish River increased from a low of 4 in 1985 to a high of 412 in 1993. Numbers of bull trout remained relatively stable from 1990 through 1996; counts during this period averaged 302 adults, and ranged from 250 to 413. More recent snorkel counts indicate a decline in numbers of adult bull trout since that time, as counts from 1998 through 2002 averaged only 95 adult bull trout (range 89 to 105; Figure 9) (Brenkman, *in litt.* 2003a).

In the South Fork Skokomish River fluvial bull trout occupy the river from its mouth upstream to a natural barrier at river mile 23.5. Snorkel surveys accounted for one to two bull trout observed each mile. The total number of adult bull trout in the South Fork Skokomish River local population is estimated by the Olympic National Forest to be around 60 individuals (WSCC 2003). Genetic analysis of 25 samples from the South Fork Skokomish River identified that the fish were bull trout (Leary and Allendorf 1997). Although bull trout occur throughout the mainstem South Fork and in a majority of tributaries, the highest densities are found above river mile 18.3. Juvenile bull trout have been observed in the South Fork Skokomish River downstream as far as river mile 0.2 and in every tributary upstream from river mile 0.2. Low numbers of multiple age classes of bull trout have been observed in the anadromous reaches of Brown, LeBar, and Pine Creeks. Higher numbers have been detected in Church Creek (Olympic National Forest, *in litt.* 2003).

Following several years of intensive surveys to locate bull trout redds (nests constructed by females in streambed gravels where eggs are deposited and fertilization occurs), 22 redds were detected in 2000 (Ogg and Stutsman 2002). Twenty redds were located in five spawning areas between river mile 19 and river mile 23.5 in the South Fork Skokomish River, and two were located in the lower 0.5 mile of Church Creek. One questionable redd was observed in Brown Creek.

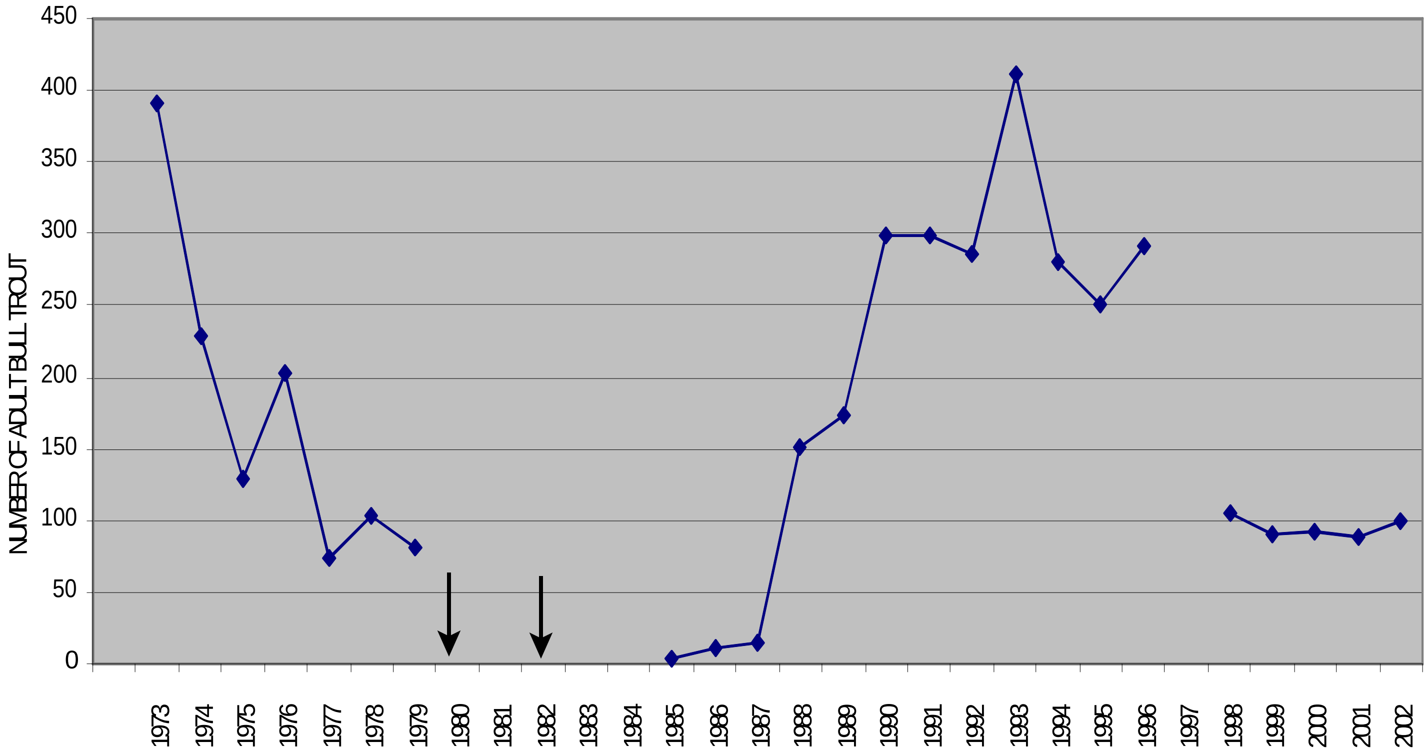

Figure 9. Annual peak count of adult bull trout in the North Fork Skokomish River, Olympic National Park, 1973 to 2002 (walking surveys 1973-1993; snorkeling surveys 1994-2002). The arrows indicate the years when fishing restrictions were first placed on bull trout (1980), followed by all fishing for char being closed (1982) in the North Fork Skokomish River.

In 2001, 20 total redds were observed, 18 in the South Fork Skokomish River and 2 in Church Creek (Ogg and Stutsman 2002). In 2002, 14 redds were observed, 13 in the South Fork Skokomish River and 1 in Church Creek. However, high flows prevented redd surveys toward the end of the spawning season (L. Ogg, pers. comm. 2003a).

Suitable spawning habitat in Church Creek is limited to the lower 0.5 mile and only one to two redds per year have been observed in that reach. It is unlikely that Church Creek could support more than a few redds. In addition to the Church Creek spawning site's proximity to the South Fork Skokomish River, other localized concentrations of redds in the upper South Fork Skokomish River watershed are in close proximity to one another. The Olympic Peninsula Recovery Team members believe this proximity of spawning sites would likely promote free movement among tributaries and sites by spawning adults from one year to the next, resulting in a single local population of fish with common genetic makeup using more than one stream or spawning area for spawning and rearing. The Olympic Peninsula Recovery Team, after substantial discussion about bull trout spawning distribution and whether one or more local populations exist in the watershed, designated the Upper South Fork Skokomish River and its colonized tributary Church Creek as a single local population.

Brown Creek watershed has been the focus of a major restoration effort by the Olympic National Forest. These restoration activities include road decommissioning and upgrading, riparian vegetation restoration, upslope vegetation enhancement, off-channel beaded pond enhancement, and instream restoration, such as instream structures and nutrient enhancement (L. Ogg, pers. comm. 2003a). Following these restoration efforts Brown Creek again supports winter and summer steelhead.

Brown Creek has many coldwater springs, over 8.5 kilometers (5 miles) of accessible habitat, and water temperatures are suitable for supporting bull trout spawning and incubation (L. Ogg, pers. comm. 2003c). In 2000, one questionable redd was observed in upper Brown Creek. This redd was smaller in size than other redds observed in the South Fork Skokomish River. Multiple age classes of bull trout have frequently been observed in the creek. The Skokomish core area currently has only two local populations. Rieman and McIntyre (1993) identified core areas with fewer than five local populations as being at increased risk of extirpation. Therefore, the Olympic Peninsula Recovery Team identified Brown Creek as a potential local population necessary to reduce risk to the core area from random, naturally occurring events that could result in extirpation of local populations. The Brown Creek local population is necessary for recovery of bull trout in the Skokomish core area.

Quinault Core Area. The Quinault core area includes all streams in the Quinault River basin. In 1995, 25 native char were collected for genetic analysis. Allozyme electrophoresis was used to identify species as Dolly Varden or bull trout (Leary and Allendorf 1997). Three fish collected from the upper mainstem Quinault (East Fork) in July 1995 were bull trout. Of the eight fish collected from the upper mainstem Quinault River (East Fork) near Enchanted Valley in September 1995, two were bull trout and six were Dolly Varden. All 14 fish collected from a small tributary in the vicinity of the September mainstem sample were Dolly Varden. Thus, the species are sympatric (co-occur) in the upper mainstem, but only Dolly Varden appear to inhabit the small tributary. There was no evidence of hybridization or introgression (Leary and Allendorf 1997). The two species are not differentiated in the fish survey, and distribution data sets are often referred to collectively as “native char.”

It is likely that the basin supports all life history forms of bull trout including adfluvial, fluvial, anadromous, and potentially, resident forms. Based on the presence of multiple age classes of bull trout, available habitat, and the judgement of the recovery team, the North Fork Quinault River and associated tributaries were identified as a local population and the upper mainstem Quinault River upstream from the confluence with the North Fork Quinault River (East Fork Quinault River) and associated tributaries were identified as a separate local population. Both local populations consist of multiple age classes of bull trout and are above 150 meters (500 feet) elevation where bull trout spawning is most likely to occur (WDOE 2002). More than two local populations likely exist although data are insufficient to define additional local populations at this time. The status of Quinault River bull trout and location of actual spawning sites are unknown.

Snorkel surveys, electrofishing, and hook-and-line sampling have been conducted in the basin. Snorkel surveys were conducted by Olympic National Park and Olympic National Forest biologists during the summer months of 1994 and 1995 in the upper mainstem (East Fork Quinault River), the North Fork Quinault River, and the mainstem from Graves Creek downstream to the North Shore Quinault Bridge (Olympic National Park, *in litt.* 2001). Large adult fish and juveniles were observed in these rivers and in Pyrite, Ignar, O'Neil, and Rustler Creeks (Olympic National Park, *in litt.* 2001).

In the North Fork Quinault River local population, multiple age classes of native char occur upstream to at least river mile 10 (Olympic National Park, *in litt.* 2001). Olympic National Park biologists documented bull trout in Irely Lake in 1993 (S. Brenkman, pers. comm. 2003a). Irely Lake flows into Big Creek, which is connected to the North Fork Quinault River.

In the upper mainstem Quinault River (East Fork) local population multiple age classes of native char have been found upstream and downstream from a potential anadromous barrier located just upstream of the confluence of Graves Creek and upstream to river mile 66 (WDFW 1998; Olympic National Park, *in litt.* 2001). Further surveys are needed to determine whether the fish upstream from the barrier are resident or migratory bull trout.

Although both bull trout and Dolly Varden may occur in Lake Quinault, the extent and distribution of these fish is unknown for most of the tributaries that drain directly into the lake. Downstream from the lake, bull trout have been identified in Cook Creek (D. Zajac U.S. Fish and Wildlife Service, pers. comm. 2002). Bull trout presence and distribution in lower river tributaries are unknown, largely due to lack of survey effort, but the migratory life forms likely occur in the mainstem and anadromous reaches of the tributaries.

Cook Creek is a major tributary that enters the lower Quinault River (downstream from the lake) at river mile 17. Three adult bull trout were observed during snorkel surveys in June 2000 (S. Craig, U.S. Fish and Wildlife Service, pers. comm. 2003) downstream from the electronic weir operated by the Quinault National Fish Hatchery (river mile 5), and a 31-centimeter (12-inch) bull trout was captured at the hatchery in January 2002 (D. Zajac, pers. comm. 2002). A fin clip sample from this fish was taken for genetic analysis and the fish was confirmed to be a bull trout. It is unknown whether fish documented in Cook Creek were migrating to spawn above or below the weir, or using the creek primarily for foraging.

The Cook Creek watershed (Cook, Elk, Chow Chow, Hathaway, and Skunk Creeks) is characterized by low gradient and numerous wetlands. The watershed contains approximately 21 kilometers (13 miles) of mainstem habitat and 40 kilometers (25 miles) of tributaries. Habitat quality is rated as fair to good with an average of 48 pieces of large woody debris per mile and a pool area of nearly 30 percent (WSCC 2001). Maximum water temperatures at the hatchery generally average 5.5 degrees Celsius (42 degrees Fahrenheit) in winter and 12.2 degrees Celsius (54 degrees Fahrenheit) in the summer. Monthly temperature data over the past 5 years indicate that stream temperatures in Cook Creek are between 6 degrees Celsius and 10 degrees Celsius (42 and 50 degrees Fahrenheit) for at least 8 months of the year. Because of the topography and proximity of the lower reaches of Cook and Chow Chow Creeks to the Quinault River valley and floodplain, it is possible that groundwater infiltration from the main river may be influencing water temperatures measured at the hatchery. The Cook Creek drainage is rainfall dominated, and it is unknown whether the system provides the consistent cold temperatures that are suitable for bull trout spawning and incubation. This watershed apparently provides foraging and overwintering habitat.

Queets Core Area. At the time of listing, we determined that the status of bull trout in the Queets River subpopulations was unknown due to lack of monitoring data that could be rigorously compared. Although the Quinault Indian Nation has a long-term data set of bull trout captured during night seining surveys, data collected since 1991 have not been analyzed. Seining data indicated an incidental catch rate fluctuating between 3.3 and 2.0 char a day from 1977 to 1981 followed by a decreased catch rate that stabilized at around 1.5 char a day from 1982 to 1991 (WDFW 1998). Several anglers interviewed by the Washington Department of Wildlife in 1992 stated that native char abundance in 1992 appeared much lower than in the previous 10 years (WDW 1992). To date, there have been no studies designed to determine trends or abundance of bull trout in the Queets basin. In their most recent bull trout status review, the

Washington Department of Fish and Wildlife (1998) considered the status of Queets River bull trout to be healthy.

In the Queets River, bull trout have been caught in the anadromous zone. Migration to marine waters by Queets River bull trout was verified in 2000 using mineral ratios in otoliths from fish that had also been genetically identified as bull trout (Leary and Allendorf 1997; Volk 2000). The migratory histories of individuals can be inferred through analysis of the strontium to calcium ratio in the otoliths, because the higher strontium content of seawater versus freshwater is reflected in strontium levels in the otoliths. The otolith core strontium:calcium values can also effectively discriminate between the progeny of anadromous and freshwater resident bull trout. The otolith core strontium:calcium values for the Queets River bull trout in the Volk study (2000) suggest that the fish were spawned by anadromous females. Migration through marine waters by Queets River bull trout has been further confirmed during a Hoh River 2003 radio telemetry study (Brenkman and Corbett, *in litt.* 2003a,b).

Results from genetic analysis of 20 samples revealed the presence of bull trout in the Queets River (Leary and Allendorf 1997). Bull trout have been observed in the Queets River up to river mile 46 (Olympic National Park, *in litt.* 2001). Bull trout have also been observed in the Salmon River (G. Ging, U.S. Fish and Wildlife Service, pers. comm. 2003), Matheny Creek near the confluence with the Queets River (N. Banish, Washington Department of Fish and Wildlife, pers. comm. 2002), Sams River (Chan, *in litt.* 2001), and Clearwater River downstream of Bull Creek (Peters, *in litt.* 2001).

Based on the professional judgement and experience of members of the recovery team, the Queets River mainstem and tributaries have been designated as mixed use (rearing, foraging, migration, overwintering), and the Queets River and associated tributaries upstream from the confluence with Tshletshy Creek have been designated as a local population (Olympic Peninsula Recovery Team, *in litt.* 2003a). This local population is above 150 meters (500 feet) elevation and is therefore within the elevation range where bull trout spawning is most likely to occur (WDOE 2002). Spawning has recently been documented in the upper Queets upstream from river mile 45 (Gross, *in litt.* 2002). Bull trout juveniles as small as 98 millimeters (3.8 inches) have been observed near the mouth of the Queets River (Quinault Indian Nation, *in litt.* 2002).

Hoh Core Area. There is no information on trends or abundance of Hoh River bull trout, and the status of Hoh River bull trout is unknown. Bull trout were historically an important food source for early settlers on the Hoh River (Powell 1999, as cited in McHenry, in prep.). Mongillo (1993) described the Hoh as historically containing the largest population of bull trout on the Washington coast, although interviews with anglers and Washington Department of Fish and Wildlife employees suggested that bull trout numbers declined in the period from 1982 to 1992 when the interviews were completed. Results from genetic analyses of fin clips to confirm species identification revealed that only bull trout, and no Dolly Varden, were present in the Hoh River (number of samples analyzed was 73) and South Fork Hoh River (number of samples analyzed was 45) (Brenkman and Meyer 1999).

Bull trout have been found throughout the mainstem Hoh River (river mile 3 to river mile 48) and South Fork Hoh River (river mile 0.2 to river mile 14) (Brenkman and Meyer 1999). No bull trout were detected in 17 of 18 tributaries of the Hoh River surveyed during 1998, despite extensive electrofishing and day and night snorkeling (Brenkman and Meyer 1999). According to the "1944 Fishing Guide To The Northwest," bull trout were historically found in Tom and Owl Creeks (McLeod 1944).

To date, there have been no surveys for bull trout in the uppermost sections of the Hoh River and Mount Tom, Jackson, and Glacier Creeks due to the lack of access. There have also been very few surveys for bull trout outside Olympic National Park boundaries, although a bull trout was recently observed in Nolan Creek (J. McMillan, pers. comm. 2002). Bull trout have been captured in salmon and steelhead fisheries at the mouth of the Hoh River. It is likely that the Hoh River basin supports both resident and migratory forms, including anadromous forms, of bull trout.

In 1998, bull trout were documented spawning in the upper Hoh River basin from October 19 to November 18, although it is likely that additional spawning areas were present but not located (Brenkman and Meyer 1999). Using the same rationale applied to the Skokomish River and its tributary spawning population for spawning sites in close proximity, bull trout found in the Hoh River upstream from the confluence with the South Fork Hoh River and associated tributaries, including “OGS” Creek, and Cougar Creek, are identified as a local population.

No bull trout spawning was observed in the lower portions of numerous tributaries to the Hoh River during weekly walking surveys from October to December 1998. In 1998, a total of 34 redds was observed from river mile 43 to river mile 48 in the Hoh River, from river mile 10 to river mile 14 in the South Fork Hoh River, in lower “OGS” Creek, and in lower Cougar Creek (Brenkman and Meyer 1999). The co-occurrence of fall spawning bull trout, coho salmon, and Chinook salmon makes it difficult to distinguish which species actually constructed a particular redd. Redds are only identified as bull trout redds if they are occupied by bull trout at the time of the survey. In 1998, no bull trout spawning was observed in the lower portions of Canyon, Jackson, Mount Tom, Snider, Taft, Tower, Twin, and Willoughby Creeks despite weekly surveys from October 13 to December 2 (Brenkman and Meyer 1999). Although redd surveys were conducted in the Hoh River and South Fork Hoh River index areas during 2002, no redds were detected.

Bull trout found in the South Fork Hoh River and associated tributaries are also identified as a local population. In the South Fork Hoh River, Olympic National Park has conducted annual “all species” snorkel surveys since 1991. The surveys are conducted in the fall, although the exact time and extent of the surveys have varied from year to year, which makes comparison of year-to-year data difficult. In 2002, however, 236 bull trout over 30 centimeters (12 inches) in length were observed from river mile 13 to the mouth. This is the highest number of bull trout counted to date during Olympic National Park’s annual all species survey in the upper South Fork Hoh River (Brenkman, *in litt.* 2003a). Using data provided in a summary of the all species snorkel surveys, a range of bull trout densities for the survey area can be described. Densities range from a low of 1 fish per mile in 2001 to a high of 18 fish per mile in 2002.

Both local populations are above 150 meters (500 feet) elevation and therefore within elevations where bull trout spawning is most likely to occur

(WDOE 2002). Further surveys and genetic analyses are needed to confirm the accuracy of this designation.

Elwha Core Area. The Elwha core area includes the entire mainstem river, all tributaries, Lake Mills, Lake Aldwell, and the estuary of the river (Figure 7). The Elwha and Glines Canyon Dams and their associated reservoirs fragment the core area and have been identified as the cause of elevated stream temperatures in both the middle and lower rivers. The Elwha River Ecosystem and Fisheries Restoration Act of 1992 (Public Law 102–495) authorizes the removal of the Elwha and Glines Canyon Dams to fully restore the Elwha River ecosystem and native anadromous fisheries. With dam removal and fisheries restoration, connectivity for the upper, middle, and lower sections of the Elwha River should also be restored, and the core area will no longer be fragmented by artificial barriers.

There is no information on the life history forms present in the basin although it is likely that anadromous, fluvial, adfluvial, and resident bull trout exist. Bull trout have been caught in Lake Mills, Lake Aldwell, in the river between the reservoirs, below Elwha Dam, and in the river upstream to river mile 44 (Brenkman and Meyer, *in litt.* 2001). Genetic analyses of 58 fin clips confirms that native char in the Elwha are bull trout (Young, *in litt.* 2001).

Bull trout have been observed each year in the Lower Elwha River and the Washington Department of Fish and Wildlife Chinook salmon rearing channel (WDFW 1998). Hatchery personnel at the Washington Department of Fish and Wildlife Elwha River Hatchery report having seen 5 to 10 bull trout each year, mainly from 1986 to 1996 (G. Travers, Washington Department of Fish and Wildlife, pers. comm. 2002). These fish averaged 250 to 310 millimeters (10 to 12 inches) and were observed mainly in the winter during high-water periods when they showed up at the intake screens while the hatchery was running on river water. In 2001, the Lower Elwha Tribe observed four bull trout during August snorkel surveys (M. McHenry, Lower S’Klallam Tribe, pers. comm. 2002b) and an angler captured a 430-millimeter (17-inch) bull trout in September and a 510-millimeter (20-inch) bull trout in December (S. Brenkman, pers. comm. 2002a). In 2002, during August through October snorkel surveys, the Lower Elwha Tribe observed seven adult or subadult bull trout in the Lower Elwha River below the Elwha Dam; in the 2003 snorkel survey 31 bull trout ranging in size from 250 to 620 millimeters were observed below the Elwha Dam (G. Pess, NOAA Fisheries, pers. comm. 2003). One to two bull trout mortalities have been observed annually in the lower Elwha River where the elevated temperature regime is likely contributing to increased disease and mortality episodes for salmonids (M. McHenry, pers. comm. 2002a.). Anglers in this reach have observed large bull trout attacking hooked rainbow trout (M. McHenry, pers. comm. 2003). It is unknown whether these bull trout in the Elwha River below Elwha Dam migrated from another core area (*i.e.*, the Dungeness), originated from parents that spawned in this lower river, or originated from parents that spawned in the more suitable, pristine habitat within Olympic National Park and then were able to move downstream past the two dams.

Bull trout tend to occur in moderately low numbers between the two dams. Both juvenile and adult bull trout have been captured in the middle Elwha and Lake Aldwell below Glines Canyon Dam (Hiss and Wunderlich 1994; Chan, *in litt.* 2001). Once the dams are removed, the Elwha River below Glines Canyon Dam will likely provide important foraging, migration, and overwintering habitat for bull trout in the Elwha core area.

Based on professional judgement, knowledge of the presence of fish in a number of drainages, and the availability of suitable habitat, the recovery team designated the Elwha River and accessible tributaries upstream from Glines Canyon Dam as a single local population (Olympic Peninsula Recovery Team, *in litt.* 2003a). In this system multiple age classes of bull trout have been observed throughout the basin, including in Boulder, Cat, Prescott, Stony, Hayes, Godkin, Buckinghorse, and Delabarre Creeks (Reisenbichler 1999; Brenkman and Meyer, *in litt.* 2001). Due to the steep terrain, many of these tributaries have limited accessible habitat. All of this local population is above 150 meters (500 feet) elevation and therefore within elevations where bull trout spawning is most likely to occur (WDOE 2002). Although spawning has not been detected in the Elwha core area, there has been little survey effort. Access to most of the core area is very difficult, and multiple age classes of bull trout have been observed above the Glines Canyon Dam. It is likely that more than one local population exists in the Elwha core area, and future surveys may indicate departures from this current single local population. There is no information on trends or abundance of Elwha River bull trout, and the status of Elwha River bull trout is unknown.

The Elwha core area currently has only one identified local population. Rieman and McIntyre (1993) identified core areas with fewer than five local populations as being at increased risk of extirpation. Based on the professional judgement and experience of members of the recovery team, and the likelihood of spawning when the Elwha and Glines Canyon Dams are removed, the Little River has been identified as a potential local population necessary for recovery in the Elwha core area (Olympic Peninsula Recovery Team, *in litt.* 2003a). The Little River has over 11 kilometers (7 miles) of accessible habitat and the habitat, including temperature conditions in the river, are suitable for bull trout spawning and juvenile rearing based on temperature data collected in 1996 by the Lower Elwha S'Klallam Tribe (McHenry, *in litt*. 2003). The temperature profile is similar to other systems where very cold groundwater is the major factor influencing stream temperatures in late summer, with very little diurnal variation (McHenry, *in litt.* 2003). The Tribe also has records of an important salmon camp historically occurring on the Little River. Morrill and McHenry (1995) also reported the presence of bull trout in this river.

Dungeness Core Area. Bull trout have been observed throughout the Dungeness River upstream to an impassable barrier at river mile 19 and in the Gray Wolf River (Peters, *in litt.* 1997). Genetic analyses of 50 samples from fish collected in the upper Dungeness River upstream from the impassable barrier at river mile 24 have identified resident Dolly Varden (Young, *in litt.* 2001), and bull trout have been identified from 25 samples collected in the Dungeness River downstream from the barrier (Spruell and Maxwell 2002). It is unknown if bull trout are present upstream from the anadromous barriers in the Gray Wolf River at the confluence with Cameron and Grand Creeks.

The core area includes spawning, rearing, foraging, migration, and overwintering habitat. Multiple age classes of char have been observed in the Dungeness mainstem, and it is likely that the core area supports fluvial and anadromous forms of bull trout (Peters, *in litt.* 1997; Chan, *in litt.* 2001). Population abundance has not been monitored in the mainstem, and few surveys have been conducted in the tributaries.

The middle Dungeness River upstream from the confluence with and including Canyon Creek and associated tributaries, including Gold, and Canyon Creeks, upstream to the impassable barrier at river mile 19, has been identified as a local population. Although spawning has not been detected in this local population (little survey effort has been made), multiple age classes have been documented (Peters, *in litt.* 1997; Chan, *in litt.* 2001), and there is suitable spawning and rearing habitat within the mainstem and tributaries to support a local population.

Based on the judgement and experience of biologists on the recovery team, documentation of redds, and the availability of suitable habitat, the Gray Wolf River has also been identified as a local population. Bull trout redds were recently documented in the Gray Wolf River between river mile 2 and river mile 4 (R. Cooper, Washington Department of Fish and Wildlife, pers. comm. 2002).

Both the Middle Dungeness and Gray Wolf local population are above 150 meters (500 feet) elevation and within elevational limits where bull trout spawning is most likely to occur on the west side of the Cascade Mountains (including the Olympic Mountains) in Washington (WDOE 2002). Future surveys may indicate changes in identification of local populations.

Summary of Status of Bull Trout and Importance of Core Areas in the Olympic Peninsula Management Unit. Olympic National Park forms a hub of pristine habitat for bull trout in this management unit. However, the Olympic Peninsula probably presents a more significant challenge for determining status, abundance, distribution, and location of spawning sites than other areas throughout the range of bull trout due to the high number of turbid glacial rivers, high rain fall and resulting high flows, and access problems. Access is limited by steep terrain combined with extensive roadless wilderness areas. While Olympic National Park provides great benefits to all fish by protecting large watersheds, and specifically to bull trout by protecting much of the assumed spawning habitat, it also hinders access needed to conduct monitoring, especially of spawning trends and population abundance.

Available data on distribution or abundance of bull trout in the Olympic Peninsula Management Unit are often limited in scope and have been collected by a variety of methods. Sources of data include historical reports, incidental bull trout counts obtained during other fish surveys, smolt and adult trap counts, creel survey data, redd count data, personal observations by biologists, radio telemetry, and adult counts. It is likely that spawner distribution and the number of local populations are underestimated and that many spawning and rearing areas have not been located and thus have been omitted. The recovery team has identified obtaining information on bull trout distribution, abundance, and spawning sites as a high priority action necessary for recovery and for monitoring and evaluating the status of bull trout in the Olympic Peninsula.

The six identified core areas all play a critical role in the recovery of bull trout in the Olympic Peninsula Management Unit. Each core area is vital to maintaining the overall distribution of bull trout within the management unit. The Skokomish core area is the only core area on the eastern portion of the Olympic Peninsula and the only core area draining into Hood Canal. It has more abundance data than any other core area in the Olympic Peninsula Management Unit. Due to low abundance (fewer than 200 adult spawners) and fragmentation of habitat, it is likely the most depressed core area in the management unit. The Dungeness and Elwha core areas are the only core areas connected to the Strait of Juan de Fuca. Little is known about the spawning abundance or distribution in either core area, although it is believed that most of the spawning and rearing habitat for the Elwha core area is located within Olympic National Park. On the coast the Queets, Quinault, and Hoh River core areas drain into the Pacific Ocean. The highest number of redds in these core areas has been observed in the Hoh River core area. The number of redds (34 in 1998) and the estimated number of adult fish spawning on those redds are fewer than what is believed to be necessary to reduce the risk from genetic inbreeding for the local populations and from genetic drift (the random change in the frequency of occurrence of a particular gene in a population) for the core area. The recovery team believes that there are additional spawning sites that have not yet been located. In the Queets core area, only a small number of redds have been located and none have been located in the Quinault River. Due to the lack of information on bull trout abundance and trends in all core areas other than the Skokomish core area, status is unknown for the Dungeness, Elwha, Hoh, Queets, and Quinault River core areas.

Important Marine, Estuarine, and Coastal River Habitat for Bull Trout. Marine waters, including coastal rivers, estuaries, and nearshore waters, provide bull trout access to a productive forage base and to overwintering areas protected from extreme flow events. Many coastal tributaries seasonally occupied by bull trout are not believed to support spawning (Brenkman and Corbett, *in litt.* 2003a,b; Olympic Peninsula Recovery Team, *in litt.* 2003a). These waters have been identified by the recovery teams as important foraging, migration, and overwintering habitat for bull trout from core areas in the Olympic Peninsula. The recovery team also identified comprehensive surveys of additional river systems with potential bull trout foraging and overwintering habitat as an important research need.

The "marine" foraging, migration, and associated overwintering habitats are important to bull trout in the Olympic Peninsula for maintaining diversity of life history forms and for providing access to productive forage areas. Based on the professional judgement and experience of members of the recovery team, all marine and estuarine waters, and independent tributaries with documented use by bull trout outside of core areas, provide habitat necessary for foraging, migration, and overwintering by core area populations on the Olympic Peninsula (Olympic Peninsula Recovery Team, *in litt.* 2003c).

Within the Olympic Peninsula Management Unit, there is confirmation of anadromous bull trout using nearshore marine waters, estuaries, or lower reaches of coastal rivers as migratory corridors and to forage and overwinter. Migration to marine waters by Queets River bull trout was first verified using otolith strontium from fish that had also been genetically identified as bull trout (Leary and Allendorf 1997; Volk 2000). In addition, the otolith core strontium:calcium values for the Queets River bull trout in the Volk (2000) study suggest that the fish were spawned by anadromous females.

In an ongoing study in Olympic National Park to determine life history, movement patterns, and anadromy in Hoh River bull trout, biologists have analyzed stomach samples from bull trout incidentally taken in lower river gill-net fisheries targeting salmon. Preliminary results indicate that prey items found in bull trout stomachs from the lower Hoh River primarily consisted of surf smelt, a marine species (S. Brenkman, pers. comm. 2003b). In the same Hoh River study, seasonal movements of bull trout implanted with radio transmitters revealed that at the onset of winter the majority of tagged fish moved from upper portions of the Hoh River into marine waters beyond the tidally influenced river mouth (S. Brenkman, pers. comm. 2003b; Brenkman and Corbett, *in litt.* 2003a,b; Olympic Peninsula Recovery Team, *in litt.* 2002). During aerial tracking along the Pacific Coast, a number of radio tagged bull trout were documented inhabiting lower portions of Cedar, Steamboat, Kalaloch Creeks, two unnamed coastal independent tributaries, and the Raft and Queets Rivers (Brenkman and Corbett, *in litt.* 2003b). The majority of tagged bull trout that moved into marine waters from the Hoh River during the winter were not located during aerial surveys in the winter and spring. The ability to locate these fish was restricted by the limited scope and frequency of flights and the inability of the radio tagged fish to be detected while in saltwater or in fresh water outside the range of the tracking equipment.

It is unclear to what degree this marine foraging behavior actually influences population structuring within the Coastal-Puget Sound Distinct Population Segment. Some level of mixing or interaction within marine waters apparently occurs among anadromous individuals from various core areas. A bull trout acoustic telemetry project in the Snohomish River estuary in Puget Sound recently confirmed the presence in the estuary of bull trout from other basins (F.Goetz, pers. comm. 2002b). Bull trout from the Hoh River basin moved south through marine waters and into the lower portions of the Quinault and Queets Rivers during the winter and spring. However, as in Puget Sound, there is currently insufficient information to understand the full extent of core area mixing within and through marine waters. Historically, anadromy could have played a role in establishing the species' distribution within the Olympic Peninsula, Puget Sound, and even within the Columbia River. Anadromy may also function as an important means for natural refounding[†] of extirpated populations.

Coastal rivers and most independent tributaries outside of bull trout core areas are unlikely to support spawning and rearing populations due to their low elevation and lack of suitable water temperatures for these life stages. However, to locate seasonally abundant prey species in these creeks and rivers, bull trout can use marine waters as a migratory corridor to move from their core area into at least the downstream portion of another river or creek basin. Because bull trout forage on salmon fry and eggs, it is believed by the recovery team that bull trout will use portions of these rivers that overlap salmon rearing (Phinney and Bucknell 1975). Bull trout may also use independent tributary mouths as freshwater "stepping stones" while migrating through marine waters and as refugia from high flows in their natal rivers during winter. Coastal and marine tributaries to Grays Harbor, the Pacific Ocean, and the Strait of Juan de Fuca where bull trout adults and subadults have been observed, but where habitat is likely unsuitable for spawning, include Goodman, Joe, Morse, Ennis, and Siebert Creeks; and the Raft, Moclips, Humptulips, Wishkah, and Copalis Rivers.

Although bull trout use of additional creek and river drainages that discharge directly into Grays Harbor, the Pacific Ocean, Hood Canal, or Strait of Juan de Fuca has not been documented, bull trout are difficult to survey (Peterson *et al*. 2002) and lack of documentation may be the result of lack of targeted bull trout survey effort. For example, bull trout had not been documented in Grays Harbor for more than 20 years (since 1981) (Simenstad and Eggers 1981). However, eight bull trout were captured during beach seining surveys conducted by the U.S. Army Corps of Engineers in Grays Harbor from March to June 2002 (Jeanes, et al. 2003). These surveys targeted bull trout rather than other salmonids.

On the coast, bull trout have been observed as far north as Goodman Creek (B. Freymond, Washington Department of Fish and Wildlife, pers. comm. 2003) and as far south as Forks Creek, a tributary to the Willapa River (M. Ackley, Washington Department of Fish and Wildlife, pers. comm. 2002). It is unknown if bull trout from Olympia Peninsula populations migrate as far east as Puget Sound and to what extent they may migrate up the coast of Vancouver Island and British Columbia.

Hood Canal and Independent Tributaries: Foraging, Migration, Overwintering Habitat. Hood Canal is relatively narrow glacier-carved fjord 98 kilometers (61 miles) long that forms the eastern portion of the Olympic Peninsula Management Unit. Early accounts of the fisheries in Hood Canal describe a great abundance of salmon and steelhead in the lower part of the canal (Hood Canal Technical Workgroup 1995). Currently, the much reduced wild salmon runs are augmented by nine State, Federal, and Tribal hatcheries, and at least a dozen small privately owned and operated salmon production facilities throughout the Hood Canal area.

As recently as the 1980's, bull trout were observed during snorkeling surveys in reaches accessible to salmon in tributaries to Hood Canal, including the Quilcene, Dosewallips, Duckabush, and Hamma Hamma Rivers (Meyer, *in litt.* 2001; P. Hilgert, R2 Consulting, pers. comm. 2000). More recent surveys by Olympic National Park in some of these rivers have not detected bull trout. Historically bull trout were observed immediately downstream of the Duckabush Fish Hatchery (U.S. Fisheries and Fish Commission, *in litt.* 1913) and in the lower reaches of the Hamma Hamma River (McLeod 1944).

The only known population of bull trout in Hood Canal is located in the Skokomish River. This river basin has been identified in this plan as a core area that is depressed and at risk of extirpation due to low numbers and fragmentation. Bull trout have been observed in the lower Skokomish River and the estuary of the Skokomish River, although the current extent of the reduced population's use of Hood Canal is unknown (Haw and Buckley, *in litt.* 1973). The Olympic Peninsula Recovery Team identified Hood Canal as important foraging, migration, and overwintering habitat for bull trout that would likely be used as the Skokomish core area increases in abundance.

Strait of Juan de Fuca and Independent Tributaries: Foraging, Migration, and Overwintering Habitat. The Strait Juan de Fuca is also a glacial fjord. It connects Puget Sound and Hood Canal to the Pacific Ocean and is located in the northern region of the Olympic Peninsula Management Unit. There are a number of small independent drainages to the strait, some of which originate in Olympic National Park. Bull trout use of these tributaries is poorly understood. Bull trout have been documented in the Strait of Juan de Fuca drainages of Bell, Siebert, Morse, and Ennis Creeks (Mongillo 1993; WDFW 1998; Freudenthal, *in litt.* 2001a,b; R. Cooper, pers. comm. 2003). Morse Creek may have suitable habitat to support a small population of bull trout. Based on current or historical habitat conditions, and the experience and professional judgement of members of the recovery team, most of these rivers and streams located between Bell and Ennis Creeks on the Strait of Juan de Fuca are not believed to support spawning populations, but do provide important foraging and overwintering opportunities for bull trout (Olympic Peninsula Recovery Team, *in litt.* 2003c). Numerous forage fish (*e.g.*, herring, surf smelt) spawning sites are found throughout the Strait of Juan de Fuca (WDFW 2000; Shaffer *et al.* 2003). Thus, the Strait of Juan de Fuca provides essential and biologically important foraging and migration habitats for bull trout.

Pacific Ocean and Independent Coastal Tributaries: Foraging, Migration, and Overwintering Habitat. The Pacific Ocean forms the western boundary of the Olympic Peninsula Management Unit. Bull trout have been documented in the coastal drainages of Cedar, Steamboat, Mosquito, Kalaloch, Goodman, and Joe Creeks and the Raft, Moclips and Copalis Rivers (McLeod 1944; Mongillo 1993; WDFW 1998; Freymond, *in litt.* 2001; B. Freymond, pers. comm. 2003; S. Potter, Quinault Indian Nation, pers. comm. 2003; S. Brenkman, pers. comm. 2003b). Based on current and historical habitat conditions, and the experience and professional judgement of members of the recovery team, rivers and streams with documented use by bull trout located between Goodman Creek and Grays Harbor are not believed to support spawning populations, but are believed to provide important foraging and overwintering opportunities for bull trout (Olympic Peninsula Recovery Team, *in litt.* 2003c).

Lower Chehalis River/Grays Harbor and Independent Tributaries: Foraging, Migration, and Overwintering Habitat. The Chehalis River system is a large basin that drains portions of the Olympic Mountains, the Cascade Mountains, the Black Hills, and the Willapa Hills before entering the Pacific Ocean. It forms much of the southern boundary of the Olympic Peninsula Management Unit. The drainage is almost entirely on State, U.S. Forest Service, or private lands. The mouth of the Chehalis River is located at Grays Harbor.

Bull trout have been historically, or are currently, documented in tributaries west of, and including, the Satsop River in the Chehalis system (Mongillo 1993). Bull trout have been caught by steelhead anglers in the Wynoochee (Keizer 1990; G. Deschamps, Chehalis Tribe, pers. comm. 1997; T. Hooper, NOAA Fisheries, pers. comm. 2004;), West Fork Satsop, and Canyon Rivers (Webster, *in litt.* 2001). Historical observations of bull trout were reported in the Humptulips River during Washington Department of Fish and Wildlife creel checks in 1958 and 1973 (Burley, *in litt.* 1997). Bull trout have recently been documented in systems that enter into Grays Harbor, such as the Wishkah and Humptulips Rivers (Dachtler, *in litt.* 2001; Ereth, *in litt.* 2002). Bull trout were reported in Grays Harbor surveys targeting other salmonids from 1966 through 1981 (Jeanes *et al.* 2003), but no additional observations of bull trout were reported from 1981 to 2001. In 2002, beach seine surveys that targeted bull trout located the species in Grays Harbor (Jeanes *et al.* 2003). Bull trout have been documented in the Chehalis River from its mouth upstream to Garrard Creek (Brix 1974; Keizer 1990; Jeanes *et al.* 2003;). In April 2003, a single bull trout was captured in the lower Chehalis River and surgically implanted with a sonic tag. Preliminary data indicated that this fish left the Chehalis River system shortly after it was tagged and did not return to the basin (Jeanes, *in litt.* 2003). It is not understood how bull trout in these rivers and the harbor interact or relate either to one another or to bull trout in the coastal core areas.

Based on the professional judgement and experience of members of the recovery team, Grays Harbor, the Chehalis River upstream to and including the Satsop River, and portions of the Wishkah, Wynoochee, and Humptulips Rivers used by salmon and steelhead, have been identified as either current or suspected bull trout foraging, migration, and overwintering habitat important for bull trout recovery in the Olympic Peninsula (Olympic Peninsula Recovery Team, *in litt.* 2003b,c). The Satsop River has also been identified as a research need area to determine the feasibility of reestablishing bull trout in the West Fork Satsop River. There are no records of bull trout use in the Hoquiam River, and bull trout use of the Hoquiam River has been identified as a research need.

Marine and Estuarine use by Dolly Varden. Dolly Varden are native char closely related to bull trout. A brief review of literature on marine use by Dolly Varden may help determine bull trout timing and extent of use of marine waters in the Coastal-Puget Sound Distinct Population Segment. Dolly Varden appear to have slightly colder water temperature requirements than bull trout, which may partially explain their Washington residency in upper watersheds upstream from anadromous barriers rather than in marine waters (Haas 2001). It is important to note that none of the research discussed in this section is based on Dolly Varden research in Washington.

Brackish water zones, including lagoons and coves, clearly provided habitat for Dolly Varden growth and rearing in Beaufort Sea coastal waters (off Alaska; Underwood *et al*. 1996). Although foraging is considered an important factor in Dolly Varden use of these waters, the constant search for thermal or salinity optima may result in apparently random movements by Dolly Varden and could obscure causal relationships. Thorpe's (1994) review of salmonid estuarine use found that anadromous Dolly Varden stay close to the shoreline. He found little evidence in the literature that the estuary was used for physiological adjustment or as a refuge from predation but did find clear evidence of a trophic advantage to estuarine residency (abundant prey). Aitkin (1998) reviewed the estuarine habitat of anadromous salmonids and found that Dolly Varden pass through estuaries while migrating and inhabit coastal waters.

Studies in Alaska have shown that Dolly Varden return to natal streams to spawn, but stocks are mixed at sea and in overwintering areas (DeCicco 1992). In a study in southeast Alaska to determine the migratory habits of anadromous Dolly Varden, Armstrong (1965) found that marked fish were found in 25 different stream systems as far as 116 kilometers (72 miles) from their natal stream. Some fish became widely distributed in a short period of time (3 to 10 days). They spent an average of 116 days in marine waters. About 40 percent of the marked fish appeared to stray or migrate to other streams during the winter. DeCicco (1992) showed that movements of anadromous Dolly Varden can be much greater than previously known (as far as 1,560 kilometers [969 miles] within 60 days), are not always coastal in nature, and suggest stocks may move over a wide geographic area, between fresh waters of Alaska and the Soviet Union.

REASONS FOR DECLINE

Bull trout distribution, abundance, and habitat quality have declined rangewide (see 63 FR 31647, 63 FR 31647, 64 FR 58910 and references therein). Within the coterminous United States, these declines have resulted from the combined effects of habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, angler harvest and associated hooking mortality[†], incidental mortality associated with fisheries for other species, poaching, entrainment (the process by which aquatic organisms are pulled through diversion channels and dams), and introduced nonnative species. Land and water management activities that depress bull trout populations and degrade habitat include forest management practices, livestock grazing, agriculture, agricultural diversions, road construction and maintenance, mining, and urban and rural development. Where applicable, the reasons for decline will be discussed in detail for each core area and important foraging, migration, and overwintering area. These reasons for decline will be presented according to the five factors identified under the Endangered Species Act, as described below.

The Skokomish watershed provides an example of the threats to bull trout that can occur from the interaction of multiple past and present activities. The degraded condition of the stream corridors, especially conditions related to road networks, timber harvest, diking, and conversion of floodplains into agricultural land and residential development, have resulted in even greater flood damage and the reduced ability of the Skokomish River to recover natural fluvial function. After each flood event, increasingly severe modifications have been made to protect roads, residences, and agricultural land in the floodplain (USDA 1995b), again resulting in greater flood damage and reduced ability to recover natural fluvial function.

In determining whether to list, reclassify, or delist a taxon under the Endangered Species Act, we consider the effects of five different factors that may have negative impacts on the species, potentially leading to its decline. Those five factors are (from section 4(a) of the Act):

- (A) the present or threatened destruction, modification, or curtailment of its habitat or range;
- (B) overutilization for commercial, recreational, scientific, or educational purposes;
- (C) disease or predation;
- (D) the inadequacy of existing regulatory mechanisms;
- (E) other natural or manmade factors affecting its continued existence.

Dams (Factor A)

Overview. Ensuring the persistence of the species requires restoring and maintaining connectivity among remaining populations of bull trout (Rieman and

McIntyre 1993). Migration and spawning among populations increases genetic variability and strengthens population viability (Rieman and McIntyre 1993). Barriers caused by human activities limit population interactions and may eliminate migratory life history forms of bull trout. Bull trout migrating downstream of dams without upstream fish passage are unable to contribute to the bull trout population upstream. Systems with multiple impassable dams can result in significant loss. Long-term effects resulting from dams in the Olympic Peninsula Management Unit include reduced native anadromous fish populations, associated loss of marine-derived nutrients, and reduced levels or loss of opportunity for genetic exchange within the core areas. The long-term effects of the dams on bull trout habitat include inundation of spawning and rearing habitat; loss of gravel recruitment, nutrients, and large instream woody debris; and increased stream temperatures due to low flows.

Another impact related to dams is injury and mortality of bull trout passing downstream over the spillway† or through power tunnels and turbines. The hydroelectric projects on the North Fork Skokomish and Elwha Rivers were constructed without any provisions for safe fish passage. Significant injury and mortality can occur during spillway passage if bull trout strike the retaining walls, projections on the spillway, or rocks below the spillway. Bull trout mortality may result during passage through the power tunnel and turbines of a single hydroelectric facility. Injury and mortality rates can vary significantly due to both fish size and the operational range of the Francis turbines in these facilities (Wunderlich and Dilley 1985; Bell 1991a,b). In an analysis of turbine-related mortalities, downstream passage mortality must be extrapolated to account for the fact that the Elwha and North Fork Skokomish Rivers each have two hydroelectric facilities.

Skokomish Core Area. The construction of Cushman Dams 1 (Lake Cushman) and 2 (Lake Kokanee), without fish passage, has had long-term impacts on water quality and connectivity in the Skokomish core area. The Cushman Dams are operated by Tacoma Power. The river is diverted through a tunnel at Lower Cushman Dam to supply a power plant in Potlatch on Hood Canal (Phinney and Bucknell 1975). The two dams prevent migration between the Upper North Fork Skokomish River and the lower North Fork Skokomish

River, mainstem Skokomish River, and Hood Canal and form a significant barrier to connectivity in the Skokomish core area.

Water levels in Lake Cushman can fluctuate up to 21 meters (69 feet), with peak levels occurring during summer and minimum levels during winter. The magnitude of these fluctuations results in periodic inundation of 12 hectares (30 acres) of land surrounding the inlet to the reservoir, resulting in high water temperatures in the shallow waters of the inlet during the summer months (Brenkman 1998). Currently, the reservoir inundates 17.2 kilometers (10.7 miles) of river, including areas of the original Lake Cushman (Brenkman 1998).

As part of the operation of this complex from 1930 to 1988, the entire flow of the North Fork Skokomish River downstream of Cushman Dam 2 was diverted to a power station near Potlatch, Washington. Since 1988, 0.85 cubic meters per second (30 cubic feet per second) of water has been released into the river, an amount equal to 4 percent of the river’s average natural flow (American Rivers 1996). The flow of the North Fork Skokomish River is largely bypassed to Hood Canal and does not contribute to the mainstem Skokomish River and Skokomish estuary. Loss of flow in the North Fork Skokomish River has resulted in reduced sediment transport capacity, loss of fish spawning and rearing habitat, reduced channel capacity, and more frequent flooding (USDA 1995b).

Reduced flows have also significantly altered sediment size and sedimentation patterns in the delta, which has resulted in increased erosion at the outer edge of the delta and increased sediment deposition† at the inner edge. These impacts to the intertidal zone have contributed to reduced biological productivity of the estuary and reduced sizes of eelgrass (*Zostera marina*) beds at the mouth of the Skokomish River. Herring, an important prey species for bull trout (Kraemer 1994), rely on eelgrass beds for spawning habitat (O’Toole *et al.* 2000). Eelgrass beds also provide important habitat for juvenile salmonids and other bull trout prey species. Loss of eelgrass beds reduces forage opportunities for bull trout in the Skokomish core area.

Elwha Core Area. Elwha and Glines Canyon Dams have had, and continue to have, long-term impacts on fisheries, water quality, and connectivity in the Elwha core area. Significant impacts to migratory bull trout in the Elwha

River began with the construction of the Elwha Dam in 1913 at river mile 5. This dam blocked all upstream migration and fragmented the Elwha into two isolated sections. The construction of Glines Canyon Dam in 1926 resulted in further fragmentation and isolation of the Elwha bull trout population. The upper Elwha River population is in Lake Mills, the mainstem Elwha River and tributaries upstream from Glines Canyon Dam, and the middle Elwha River population is in Lake Aldwell and its tributaries between Glines Canyon and Elwha Dams.

In the mainstem Elwha River downstream from the Elwha Dam suitable spawning habitat is extremely limited due to lack of spawning gravel recruitment, the predominance of large substrate (large cobbles and boulders), and high water temperatures. Recruitment of spawning gravels has been impeded by the two dams for nearly 100 years. Water temperatures are elevated by solar warming of the two reservoirs (McHenry 2002). It is unlikely that significant or viable bull trout spawning occurs in this lower part of the river, and the anadromous life history form in the Elwha core area has largely been eliminated by construction of the two dams. Natural production of salmon is now limited to just a few areas in the lower river, and hatchery supplementation is necessary to maintain production of summer/fall Chinook salmon, fall coho salmon, and winter steelhead. It is unknown whether bull trout observed downstream from Elwha Dam originate from the Elwha River upstream from the dams or migrate from an adjacent basin, such as the Dungeness River.

Bull trout have been reported to occur in low numbers between the two dams, in Lake Mills, and in three tributaries (Griff and Hughes Creeks and Little River) within this reach (Hiss and Wunderlich 1994; Brenkman and Meyer, *in litt.* 2001). Habitat between the dams is impacted by the interception and trapping of nutrients, gravels, and large woody debris by Lake Mills, and solar warming that occurs because of the longer retention time and the large surface area of the reservoir. The habitat upstream of Lake Mills is entirely within Olympic National Park and exhibits good bull trout habitat conditions. Despite insufficient information on the abundance and status of bull trout upstream from the dams, the available information and suitable habitat conditions indicates much better conditions for bull trout upstream from Lake Mills than for bull trout in the lower river.

The dams on the Elwha have also impacted the estuary, beach morphology, and eelgrass beds. The dams have prevented recruitment of fluvially transported sediment, and at least 366 meters (1,200 feet) of shoreline has been eroded during the period from 1939 to 1994 (WSCC 2000a).

Forest Management Practices (Factor A)

Overview. Although timber harvest continues throughout the Olympic Peninsula, it is no longer the major economic base in this region. Past forest management practices have left long-term impacts, and stream systems continue to be impacted from these practices even today.

The Olympic Peninsula has a long history of timber harvest, beginning in the mid-1880's. Much of the lowlands initially harvested for timber have been subsequently cleared for agriculture and residential development. The mainstem reaches of all core areas, except the Queets and Elwha core areas (which are almost entirely within the boundaries of Olympic National Park), have been impacted by past timber harvest (McHenry *et al*. 1998). In the Queets core area tributaries and rivers outside of the national park boundaries (*i.e*., Clearwater and Salmon Rivers, Matheny Creek) have been impacted by timber harvest.

Early riparian and stream clearing and the construction of splash dams[†] to facilitate water transport of logs were common practices in western Washington streams (Sedell *et al*. 1991). Repeated splash damming resulted in major long-term damage to fish habitat as the practice caused severe scouring[†] of stream channels, often down to bedrock (Murphy 1995). In tributaries too small for splash dams, trees were typically yarded downstream, degrading stream channels and banks in the process. Railroad systems were also constructed for transporting timber to mills in many watersheds. Although these forest management practices improved by the 1950's, clear-cutting to the streambanks remained a common practice until the 1980's. In the 1970's, forest practice rules began to require the removal of logging debris from streams after timber harvest (Murphy 1995); however, this resulted in complete clearing of large woody debris from many streams. Until recently, State forest practices allowed timber harvest to occur within 7.6 meters (25 feet) of salmon streams; these minimum widths were often insufficient to fully protect riparian ecosystems (USDI *et al.* 1996a).

The current impacts of timber harvest on bull trout habitat have likely been reduced with implementation of new Washington State Forest Practices Rules on private lands (Washington Forest Practices Board 2001) and implementation of the Northwest Forest Plan Aquatic Conservation Strategy (USDA and USDI 1994 a,b; see "Ongoing Conservation Measures" in this document) on public lands. However, the Washington State Forest Practices Rules are complex and have not been implemented long enough for monitoring or evaluation to determine the amount of conservation benefits that will be derived from protecting and improving aquatic habitat. The Northwest Forest Plan Aquatic Conservation Strategy is currently undergoing review and may be revised in the future.

Timber harvest and associated activities, such as road construction and skidding[†], can increase sediment delivery to streams, clogging substrate interstices and decreasing stream channel stability and formation (effects from forest road networks are discussed in the "Transportation Networks" section under "Reasons for Decline"). Harvest in riparian areas decreases woody debris recruitment and negatively affects the stream's response to runoff patterns. Stream temperatures rise with decreases in the forest canopy[†] and riparian zone shading. Runoff timing and magnitude can also change, delivering more water to streams in a shorter period, which causes increased stream energy and scour and reduces base flows during summer months.

Forestry practices on the Olympic Peninsula have included instream salvage, stream cleaning, and the conversion of old-growth coniferous riparian forests to young stands of deciduous species. These practices have altered both the abundance and recruitment of large woody debris, especially decay-resistant conifers, such as western red cedar (*Thuja plicata*), in Olympic Peninsula streams. The large woody debris in many streams is now dominated by smaller diameter alder (*Alnus* spp.) that tends to decay quickly and exert less influence on channel forming processes. Such wood is often too small to influence river channel hydraulics, especially the formation of pools in large mainstem rivers. Future effects of this lack of large wood recruitment will be evident as recruitment of old-growth wood is lost (McHenry, in prep.). The rapid loss of large wood from streams may also be related to increased flooding and sediment in channels modified by intense logging (McHenry *et al.* 1998).

Clear-cutting large blocks of timber has been the prevalent logging method. Where this occurs on steep slopes it often results in slope instability, mass wasting† (landslides), high silt loads, and reduced water quality. In addition, studies have shown that large trees in temperate coastal rainforests collect moisture from fog, and this collection of moisture may contribute an estimated 35 percent of the annual precipitation (Quinault Indian Nation and USDA 1999).

Recreational activities (*e.g.,* camping, trail use, off-road vehicle use) in forested areas have often caused significant localized impacts. These are typically associated with riparian vegetation removal and degradation, sedimentation, and degradation of streambanks and channels. Some of these impacts have facilitated bull trout access to staging and spawning areas, but have also resulted in increased illegal harvest.

Skokomish Core Area. The 1995 Skokomish Watershed Analysis (USDA 1995b) identified the South Fork Skokomish River watershed as highly erosive due to extensive logging and high road densities. Harvest management activity throughout the South Fork Skokomish River watershed has been extensive, with 21,246 hectares (52,500 acres) harvested since 1915 and 756 kilometers (470 miles) of new road construction. As of 1995, approximately 60 percent of the watershed had been harvested. The remaining 40 percent of the watershed was either old-growth forest or alpine vegetation (USDA 1995b).

Most timber harvest in the Skokomish watershed has been accomplished by clear-cutting. Recent clear-cutting in the mid-elevation and higher elevation forests removed some of the oldest stands that had survived multiple large fires in the past (USDA 1995b). Clear-cutting in several subwatersheds† within the Skokomish River watershed was accelerated, in part, by the existing Shelton Cooperative Sustained Yield Unit agreement with Simpson Timber Company. Timber harvest has been the primary land use in the upper South Fork Skokomish River, which has impacted the sediment supply of the lower watershed and mainstem Skokomish River. Past timber practices in Vance Creek and the South Fork Skokomish River watersheds have resulted in increased sediment and aggradation as a result of mass wasting and road failures.

Significant portions of the 21 subwatersheds in the Skokomish watershed have been classified as “hydrologically immature” largely due to timber harvest activities, and to a lesser extent, agricultural and residential development. Alterations to aquatic habitat from these activities include an increase in fine sediments, channel aggradation, changes in the natural flow regime[†], loss of in-channel woody debris, and elevated stream temperatures (USDA 1995b).

Although some timber management activities are expected to continue in the future, the majority of U.S. Forest Service lands in the upper South Fork Skokomish River watershed are classified as Late Successional Reserves. In these areas, clear-cut harvest currently is severely restricted, as is commercial thinning of stands over 80 years old. Although effects from past timber harvest are significant, future timber harvest activities are expected to be significantly reduced.

Quinault Core Area. Timber harvest in the Quinault Valley began in 1916 with the salvage of cedar trees from the 1,200-hectare (3,000-acre) “Neilton Burn,” a wildfire that was started by land clearing activities and is now the site of the community of Neilton. Between 1917 and 1940, railroads provided access to the lower Quinault River valley, accelerating logging activities in the lower watershed and tributaries. This early logging removed trees all the way to the stream edge and left no riparian buffers. Logging on the Quinault Indian Reservation began in the 1920's with several large timber sales in the Moclips River, Cook Creek, and Lake Quinault areas followed by the Boulder, Taholah, and Crane Creeks sales in the 1950's. During this time, much gravel was removed from the river to build the railway system (Quinault Indian Nation and USDA 1999).

By the late 1940's, most of the low elevation forests had been harvested and focus shifted to the mid-elevation watersheds, including the headwater areas of Cook, Skunk, North and South Boulder, Prairie, and Canoe Creeks, and Higley Ridge, Quinault Ridge, and Wrights Canyon. Extensive road construction and timber harvest activities continued to move up the basin after 1950, and by 1990 most of the old-growth forests outside of the park boundary, the Colonel Bob Wilderness Area, and a few small administratively withdrawn natural areas, had been logged (Quinault Indian Nation and USDA 1999, WSCC 2001). Clear-cut harvesting of regenerated stands is continuing on the Quinault Indian Reservation, Washington Department of Natural Resources lands, and on private lands but was virtually stopped on the Olympic National Forest with the adoption of the Northwest Forest Plan in 1994 (USDA and USDI 1994 a,b).

The steep topography and shallow soils of the upper watershed generate both a quick hydrologic response and a high susceptibility to mass wasting events. In contrast, the relatively flat terrain and outwash silts and clays downstream of the lake cause a low susceptibility to mass wasting events and a slower hydrologic response. Because Lake Quinault traps all sediment coarser than silt, the substrate in the river downstream of the lake is a product of the interactions between the floodplain and the surrounding coastal plain.

Loss of riparian and upland vegetation and road construction has impacted bank stability, recruitment of large woody material, floodplain functions, and stream temperatures. Due to the history of intensive timber management, tributaries in the middle and lower watershed have experienced elevated occurrences of slope failures as well as altered peak flows[†] (Quinault Indian Nation and USDA 1999, WSCC 2001). The watershed analysis team rated the hydrologic maturity of the lower Quinault, Cook, and Elk Creeks as “poor.” The increased risk of flooding caused by changes in peak flows has led to flood prevention measures, including channel dredging in Finley, Falls, and Kestner Creeks.

Removal of mature vegetation may increase the incidence of seasonal low flows in Olympic Peninsula streams. Severe low flows have resulted in 19 percent of the channel in Big and Prairie Creeks, 17 percent of Inner Creek, and 9 percent of No Name Creek going dry during the summer (Quinault Indian Nation and USDA 1999). Elevated levels of mass wasting and bank erosion have contributed to sediment aggradation in lower gradient systems, such as Zeigler, Inner, and Big Creeks, giving these systems “poor” ratings for streambed stability.

The watershed analysis rated pool habitat in the Quinault Watershed overall as “good” but noted that pool habitat quality was only “fair” in Camp Creek, “poor” in Big Creek, and “poor” in portions of Ten O’Clock and Prairie

Creeks. Surveys conducted by the Quinault Indian Nation in 1996 in Mounts, Ten O'Clock, Camp, Canyon, Railroad, Prairie, Cook, and Dry Creeks indicated that substrate conditions and levels of woody material are improving in some reaches of these streams (Quinault Indian Nation and USDA 1999).

Riparian shade and large woody material are at historical levels within Olympic National Park and the upper watershed, but decrease in direct proportion to the history of timber harvest activities downstream of the park boundary. While the riparian conditions in the mainstem of the Quinault River are generally rated as "good," the lack of mature vegetation is contributing to elevated temperatures and low levels of wood in lower Cook, Chow Chow, Prairie, Mounts, and Railroad Creeks and the upper headwater areas of many tributaries in the lower watershed.

Queets Core Area. With the creation of Olympic National Park in 1938, and the addition of the Queets Corridor to the park in 1953, approximately 85 percent of the mainstem Queets River was protected from logging. Riparian conditions and water quality in the mainstem are good upstream from the confluence with the Clearwater River, and overall basin conditions are considered to be at historical levels upstream from the confluence with the Sams River (WDFW 1998; WSCC 2001).

Timber harvest began in the 1940's outside the park boundary in the Sams, Matheny, Salmon, and Clearwater drainages. As occurred elsewhere on the Olympic Peninsula, logging activity peaked between 1960 and the mid-1980's. Data are lacking for large woody material levels in the mainstem and many of the tributaries in the watershed, although surveys in Elk Creek (in the lower portion of the basin) have shown a declining trend in the number of large pieces of wood in the channel (Quinault Indian Nation and USDA 1999).

Removal of the riparian trees and the lack of large woody debris have contributed to channel widening, aggradation, and loss of off-channel habitats in Matheny Creek and low gradient sections of the mainstem of the Sams River (USDA 1995a, 1997; Quinault Indian Nation 2000). Removal of the riparian trees and a lack of large wood have also impacted water quality in several other basins. For example, logging has led to increased sedimentation, elevated stream temperatures, and a lack of large woody material in the Clearwater and Salmon Rivers (WSCC 2001). Research has found that mortality of salmon in the Clearwater River was largely caused by harvest-related landslides, chronic sediment input from logging roads, blockage of access to habitat, and loss of mature riparian vegetation. In the Salmon River, most of the mainstem and tributaries have low potential for recruitment of large wood and levels of fewer than one piece per channel width resulted in a “poor” rating for this subbasin. Removal of large wood during stream clean-out efforts in the 1970's often worsened conditions. In 1972, 3.4 logjams per kilometer (2.1 logjams per mile) were recorded in the North, Middle, and South Forks of the Salmon River, but by 1973 most of these had been removed (WSCC 2001).

Timber harvest activities have also impacted the hydrology and bedload† (larger sediment particles, such as gravel and boulders, that are not in continuous suspension in streams) composition of channels in the managed watersheds. The most notable change between managed and unmanaged conditions is a difference in the character of debris flows. In confined channel reaches, such as the upper Matheny Creek, and the Sams, Salmon, and upper Clearwater Rivers, pre-management debris flows tended to have narrow tracks and carry large quantities of wood, often resulting in channel spanning logjams. In contrast, debris flows moving through managed plantations scour larger paths, pick up more sediment, are more frequent, and transport less wood (USDA 1995a). The Salmon River Watershed Analysis Team estimated that timber harvest activities accounted for 51 percent of the landslides, and logging roads caused 25 percent of the mass wasting events (Quinault Indian Nation 2000). The density of landslides, both natural and management related, is very high in the Sams River and North Creek watersheds. Of the management-related mass wasting events, most were associated with slope failures in clear-cuts and loss of fill on steep side-cast roads and perched landings. Changes in timber management and efforts to close and stabilize roads, particularly on National Forest lands, is expected to reduce the magnitude of this problem.

Hoh Core Area. The upper mainstem Hoh River and upper South Fork Hoh River lie within Olympic National Park and have had little impact from forest practices. The Hoh River drainage outside of the park has been heavily logged. The middle Hoh River is largely surrounded by private landowners and

Washington Department of Natural Resources lands. The lower Hoh includes lands within the Hoh Indian Reservation. Impacts from current forest management likely will still occur on private lands. More protective State forest practice rules, however, should make these impacts less severe than in the past, when there were very few regulations.

In the middle Hoh River and its tributaries, much of the late successional riparian forest has been removed, and without protective buffers being required, many riparian forests were logged to the stream bank. Following this riparian logging, many miles of riparian forest have been converted to younger stands, often dominated by deciduous trees. Within the middle section of the Hoh River, areas identified as having a scarcity of large woody debris include the mainstem Hoh River downstream of its confluence with the South Fork Hoh River, as well as Pins, Winfield, Elk, Willoughby, and Maple Creeks, and several unnamed tributaries (WSCC 2000b).

Clear-cut harvest on steep slopes within the Hoh River drainage is another legacy[†] of past forest management that has resulted in increased incidences of mass wasting, and within the middle Hoh River, a widespread incidence of channelized landslides (McHenry, in prep.). In the Huelsdonk Ridge area of the middle Hoh River, landslides have increased six to seven times above historical levels, with increases associated with clear-cutting (63 percent) and roads (27 percent).

Debris flows have become common in the Hoh River, resulting in a reduction of macroinvertebrates, which are primary food items for salmonids. Populations of macroinvertebrates are 75 percent higher in Olympic National Park reaches compared to areas impacted by debris flows (WSCC 2000b). The spawning gravels in Hoh River tributaries have been impacted by these channelized landslides. It is more difficult to assess the impacts of this increased sedimentation on the mainstem Hoh River because the mainstem is already heavily influenced by glacial flour (very fine-grained silt suspended in the water) from several active glaciers.

Channel morphologies in several tributaries have been altered by the combination of mass wasting and loss of large wood. This combination has resulted in pool area and quality being significantly reduced as pool-riffle morphologies are converted to plain-bed or glide morphologies. Pools provide important habitat for bull trout staging, foraging, and seeking cover. Examples within the middle Hoh River where this reduction has been observed include Owl, Alder, Spruce, Willoughby, and Winfield Creeks (McHenry, in prep.).

Elevated water temperatures are the result of loss of riparian vegetation in the mainstem Hoh River, lower South Fork Hoh River, and several adjacent tributaries (WDFW 1998). Fisher, Willoughby, Rock, Elk, Canyon, Anderson, Alder, Line, Maple, Nolan, Owl, Split, Tower, and Winfield Creeks were listed on the Washington Department of Ecology’s 303(d) list and also are on the 1998 Candidate 303(d) for high water temperatures (WSCC 2000b). Section 303(d) of the Clean Water Act (33 USC 1251 *et seq*.) requires that States periodically prepare a list of all surface waters for which beneficial uses (*e.g.*, drinking, recreation, and aquatic habitat) are impaired by pollutants.

Several tributaries in the Hoh have been impacted by cedar spalts, waste wood left over from cedar salvage operations. Large instream accumulations of spalts can block fish passage, impede water flows leading to warmer water temperatures, and degrade water quality by leaching tannins into the water. Cedar spalts can form “dams,” and as the dams float up and down in high and low flows, they carve stream banks and increase fine sediments. In riparian areas impacted by spalts, the wood often covers the ground, inhibiting further plant growth. Areas impacted by cedar spalts include Anderson, Willoughby, Winfield, Nolan, Braden, Clear, Red, Lost, Pins, and Snell Creeks (WSCC 2000b).

Elwha Core Area. Approximately 85 percent of the watershed is located within the Olympic National Park, and this part of the watershed is in excellent condition with little impact from forest management activities. Impacts from current forest management will likely still occur on private lands. More protective State forest practice rules, however, should make these impacts less severe than in the past, when there were very few regulations.

Little River, a potential local population, is located outside of Olympic National Park, and commercial timber harvest and housing development have impacted water quality (WSCC 2000a). Increased sediment from logging has been identified in the Little River. Although this is not a major threat, fine sediment can affect bull trout egg incubation success and juvenile rearing.

Dungeness Core Area. Timber harvesting has affected the occurrence and distribution of most vegetation types in the Dungeness River watershed. Impacts from current forest management will likely still occur on private and Olympic National Forest lands, but the Northwest Forest Plan Aquatic Conservation Strategy and more protective State forest practice rules should make these impacts less severe than in the past.

All forest successional stages are present in the watershed, and currently the greatest majority are in the mid-successional stage. In the lower Dungeness River watershed, below approximately 472 meters (1,550 feet) elevation, most forest vegetation has been permanently removed and converted to nonforest vegetation. In the middle elevations of the watershed, timber harvesting by clear-cutting has targeted old-growth forest communities. The upper elevation forest vegetation zones are incorporated within Olympic National Park and wilderness areas where logging is prohibited.

A total of 6,123 hectares (15,130 acres) of the Dungeness River watershed on National Forest and Washington Department of Natural Resources lands has been either clear-cut or commercially thinned since 1940. This does not include the acres harvested on private forest lands nor does it include the forested area in the lower watershed that has been permanently modified since 1850 by agricultural, urban, and residential development. The 6,123 hectares (15,130 acres) represents a total of 8.5 percent of the entire watershed area, but totals 32 percent of the combined Washington Department of Natural Resources and National Forest area (excluding designated Wilderness Areas) available for harvest since 1940 (USDA 1995c). The majority of the clear-cut harvest activity in the watershed has occurred in five of the subwatersheds: Gold, Johnson, McDonald, and Siebert Creeks and the upper Dungeness River. In Gold Creek, a major landslide (deep-seated failure) is still active and is a chronic contributor of sediment to the creek. The upper Dungeness watershed is inherently unstable due to primary geologic characteristics, and of the sediment annually deposited in the Dungeness River, 58 percent is from undisturbed forest areas and 42 percent is associated with disturbed or clear-cut areas (WSCC 2000a).

Chehalis River/Grays Harbor Foraging, Migration, and Overwintering Habitat. The Chehalis Basin has been impacted by a wide variety of disturbances. Logging, agriculture, and grazing in the basin have degraded habitat by removing riparian vegetation, increasing silt loads, and decreasing woody debris (Hiss and Knudsen 1993; WDFW 1998). Pulp mills in the lower river have also impacted habitat through discharge of effluents that range from toxic to benign (WDFW 1998). The lower mainstem of the Chehalis River has at least nine sites that are included on the 1998 Washington Department of Ecology proposed 303(d) list for not meeting temperature, dissolved oxygen, fecal coliform, and polychlorinated biphenyl (PCB) standards (WDOE 1998). Impacts from current forest management will likely still occur on private and Olympic National Forest lands, but the Northwest Forest Plan Aquatic Conservation Strategy and more protective State forest practice rules should make these impacts less severe than in the past.

Goodman Creek, and Moclips, Copalis, and Raft Rivers: Foraging, Migration, and Overwintering Habitat. Habitat in the Goodman Creek and the Copalis and Moclips Rivers has been degraded by past logging activities (WDFW 1998). Phinney and Bucknell (1975) noted that logging activities in the Moclips watershed have reduced the former fisheries potential of this system. In the Raft River drainage, riparian areas have also been heavily logged. Siltation of the gravel due to these activities is excessive in many of the tributary streams. In Goodman Creek, natural low flows in the summer (WDW 1992) and the loss of riparian vegetation from past logging may have created a thermal barrier for migrating bull trout. Impacts from current forest management will likely still occur on private and Olympic National Forest lands, but the Northwest Forest Plan Aquatic Conservation Strategy and more protective State forest practice rules should make these impacts less severe than in the past.

Agriculture (Factors A and E)

Overview. The Skokomish and Dungeness core areas have both current and long-term historical effects from agriculture that impact fisheries, water quality, and connectivity. The most significant impacts have generally been restricted to the lower elevation areas of watersheds, estuarine and nearshore areas, or along floodplains of mainstem river reaches. Agricultural practices have regularly included stream channelization and diking, large woody debris and natural riparian vegetation removal, use of herbicides and pesticides, and bank armoring that have degraded and simplified aquatic and riparian habitats (USDA 1995a; Spence *et al*. 1996; WSCC 2000a).

Functioning estuaries provide important habitat for rearing salmonids and other bull trout forage species. In some cases, tidally influenced habitats have been significantly reduced as a result of extensive diking and the placement of tidegates. Tidegates can impair fish passage and severely limit the saltwater exchange with the historical estuary. Although flood control measures (*e.g*., diking) protect agricultural, residential, and urban development interests, they can negatively impact bull trout.

Agricultural lands have often been further altered by conversion to residential and urban developments. The impacts associated with this conversion have been addressed under “Residential and Urban Development.”

Skokomish River Core Area. The lower Skokomish River, also referred to as the mainstem, flows through a broad valley of agriculture, rural hobby farms, and rural development. Significant vegetation change in the lower Skokomish Valley and riparian areas began during the late 1800's with the agricultural development of the fertile floodplains. Conversion of forest to agricultural development is evident throughout the valley. Several family farms currently operate in the Skokomish Valley, producing feed for livestock, hay, vegetables, and Christmas trees.

The concentration of agricultural development in close proximity to the Skokomish River has had a significant impact on natural conditions in the river (USDA 1995b). The majority of the mainstem Skokomish River has been diked, armored, and/or channelized, which has eliminated access to important side channels, sloughs, and wetland habitats (WSCC 2003). A combination of reduced transport capability from water withdrawal and accelerated sediment supply from logging activities, channelization, and levee construction has resulted in streambed aggradation (WSCC 2003). As diking restricts flooding flows from distributing sediments onto the floodplain, the aggradation in the streambed increases, leading to further diking, dredging, and aggradation.

A majority of the riparian vegetation along the lower Skokomish River and its tributaries has been removed or modified for farming, timber production, or flood protection, reducing the amount of wood entering the river system for fish habitat. Many of the riparian trees that do enter the river in this area are salvaged or removed for firewood or flood control. Loss of riparian vegetation has also reduced streambanks stability.

Vance Creek, the largest tributary to the Skokomish River, has also been diked, channelized, and armored. These actions have greatly reduced channel complexity, stability, and sinuosity. Gravel deposits are 91 meters (300 feet) wide in some places and the stream is commonly dry or subsurface during late summer months (WSCC 2003).

Dungeness Core Area. Rural and agricultural land comprises 14,504 hectares (35,838 acres) or 21 percent of the watershed and includes pasture, hayland, cropland, and private woodlots. The rural and agricultural area is generally located between forest lands and incorporated urban areas. Impacts from agriculture have occurred historically and continue to occur although best management practices are being implemented in some areas to reduce adverse impacts to salmonids.

Instream flow reduction due to irrigation withdrawals has been a long-standing concern in the Dungeness River. The extensive irrigation system within the Dungeness Valley is unique in western Washington (WSCC 2000a). Beginning in 1896, the Dungeness River became a source of water to convert the dry land into productive farming. By 1921 there were nine organizations diverting water from the Dungeness River to irrigate agricultural land. By 1998 the irrigation system contained approximately 100 kilometers (62 miles) of main ditch canal and another 179 kilometers (111 miles) of secondary ditches and laterals (Montgomery 1999 in WSCC 2000a). Seventy to 80 percent of the agricultural land in the Dungeness Valley is irrigated from water diverted from the Dungeness River and area streams through this extensive network of irrigation ditches. Diversion of water for irrigation that results in low flows impacts bull trout by blocking migration during late summer-early fall, decreasing juvenile rearing areas, transporting pollutants through irrigation flow returns, and increasing water temperatures and aggradation of the streambed (WSCC 2000a).

Temperature data show a trend of increasing mean temperature since the 1950's. Rearing habitat is seasonally limited by water withdrawals and elevated temperature in the lower river (WSCC 2000a).

Bedload aggradation in some portions of the lower river, which has affected fish access in the Dungeness River, will require river flows to be much higher than in the past to provide the same depth of water in the main channel and access to side channels. Increased flow requirements resulting from identified areas of bed aggradation suggest that irrigation diversion currently poses a greater problem than it did historically (WSCC 2001).

Concurrent with the development of an irrigation system in the Dungeness Valley, flood and erosion control activities were being undertaken to protect agricultural lands, and later the rural development occurring when agricultural lands were converted for housing development. Alterations from diking are most evident in the lower Dungeness downstream from the Washington Department of Fish and Wildlife Dungeness Hatchery at river mile 10.8. By eliminating connectivity of the river to its floodplain, these dikes prevent high flows from moving into the floodplain to reduce stream energy and to store and transport sediment. Dikes originally constructed to accommodate a 100-year flood now are barely able to accommodate a 27-year flood, due to the aggradation of sediment in diked portions of the channel (WSCC 2000a). Diking that constricts or eliminates the connectivity of the main channel with the full extent of the meander within the floodplain also adversely affects or eliminates the availability of side channel habitats.

Historically, when the valley was being developed for agriculture, the removal of large wood and logjams from the Dungeness River was a prominent element of flood control actions. Wood in the river is now primarily composed of small pieces located mainly outside the channel, with few key pieces available to form logjams. Removal of debris jams has resulted in increased water velocities, with associated channel instability and bank erosion (WSCC 2000a).

The Dungeness River is on the Washington Department of Ecology 303(d) list of impaired water bodies for instream flows. Water rights to the Dungeness River actually exceed actual flows. Extensive irrigation systems in the

Dungeness not only decrease instream flow, but these decreased flows likely contribute to elevated water temperatures. Temperature data for the lower river indicate a trend of increasing mean temperature since the 1950's (Clark and Clark 1996 in WSCC 2000a). The largest contributor of nonpoint source pollution in the Dungeness watershed was identified as agricultural activities, including direct animal access to waterways and irrigation diversions and laterals that direct field-applied pesticides and fertilizers into the river (WSCC 2000a).

Although the amount of estuarine wetlands has not declined significantly in the Dungeness River estuary, both the character and function of the estuary appear to have changed from historical conditions (WSCC 2000a). Diking of the lower Dungeness River has eliminated the ability of the river to use the floodplain to transport and store peak flows and associated sediment across the floodplain. The routing of the river flow within the current primary channel has eliminated virtually all historical low gradient and salt marsh estuarine habitat that provided excellent rearing and foraging habitat for bull trout.

An associated nearshore habitat concern is the loss of eelgrass in the shallow intertidal areas. Eelgrass provides valuable habitat for a variety of marine species important to the bull trout prey base, including rearing juvenile salmonids and spawning herring (O'Toole *et al.* 2000). To accommodate residential and urban development it is likely that extensive eelgrass meadows have been eliminated with filling of intertidal areas, bank armoring, and modifications of shoreline morphology.

Transportation Networks (Factor A)

Overview. Dunham and Rieman (1999) found the density of roads at the landscape level to be negatively correlated with bull trout occurrence. Roads facilitate excessive inputs of fine sediment, alter hydrology, and degrade habitat in streams. Roads also increase human access, which may cause angling mortality, introductions of nonnative fishes, and increase the potential for water pollution through impervious surfaces and accidental spills (Spence *et al*. 1996; Trombulak and Frissell 2000).

The preservation and reconnection of remaining stronghold areas and associated high quality habitats for the species is a widely held principle of managing for the survival and recovery of threatened and endangered aquatic species. In an analysis of the Swan River basin in Montana, a bull trout stronghold of regional significance, bull trout redd numbers were negatively correlated with the density of logging roads in spawning tributary streams (Baxter *et al.* 1999). Wilderness, National Park land, and roadless areas contain most of the best available remaining habitat for bull trout, steelhead, and salmon (Frissell 1993; WDFW 1998).

The Skokomish, Dungeness, Hoh, Queets, and Quinault core areas have both current and long-term historical effects from roads and transportation networks that impact fisheries, water quality, and connectivity. Large networks of forest haul roads, skid trails/roads, and yarding corridors now exist in many Olympic Peninsula watersheds. The road network is so large that much of it cannot be maintained to current regulatory standards. Much of this road network crosses or parallels stream channels, leaving a legacy of problems, such as chronic bank erosion, debris flows, fish passage barriers, chronic delivery of fine sediments, and slope failures. Although the majority of impacts to the aquatic habitat are from long-term historical effects of roads, new roads continue to be constructed. Rashin *et al*. (1999) found that best management practices used, even in new road construction, were generally ineffective or only partially effective at preventing chronic sediment delivery to streams when the activity occurred near streams.

Road density is one measurement of the impact of roads on a basin. In the Columbia Basin, a recent assessment revealed that increasing road densities and their related effects are associated with declines in the status of four nonanadromous salmonid species: bull trout, Yellowstone cutthroat trout (*Onchorynchus clarki bouvieri*), westslope cutthroat trout (*Onchorynchus clarki lewisi*), and redband trout (*Onchorynchus mykiss gibbsi*) (Quigley and Arbelbide 1997). The assessment determined that bull trout were less likely to use highly roaded basins for spawning and rearing, and if a bull trout population was found, it was less likely to be at strong population levels (Quigley and Arbelbide 1997). Quigley *et al*. (1996) demonstrated that, where average road densities were between 0.4 and 1.0 kilometers per square kilometer (0.7 and 1.7 miles per square mile) on National Forest lands, the proportion of subwatersheds supporting "strong" populations of key salmonids dropped substantially, declining even further with higher road densities.

On the Olympic National Forest a threshold density of 1.5 kilometers of road per square kilometer (2.5 miles per square mile) of basin was developed in 1990 by an interdisciplinary team as part of an evaluation process for watershed conditions (USDA 1995c). Road density data were also used to prioritize areas of concern and in need of restoration. The density threshold used by the Olympic National Forest is higher than that found by Quigley *et al*. (1996) to support "strong" populations of salmonids.

Impacts to bull trout habitat from roads and transportation networks are significant in all core areas except the Elwha core area. Assessments of road densities reported for many watersheds in the Olympic National Forest are much higher than the densities reported by Quigley *et al*. (1996) (USDA 1995a,b,c). Furthermore, the Quigley *et al*. (1996) assessment was conducted east of the Cascade Mountains, but the effects from high road densities may be worse in western Washington. The highest precipitation in the State is found on the Olympic Peninsula, which increases the frequency of surface erosion and mass wasting (USDI *et al*. 1996b).

In analysis of impacts to streams from roads, an additional factor to consider is the location of the road in the watershed. In general, the farther a road is upslope of a stream and/or the flatter the topography, the less potential for sediment incursion into a stream or adverse alteration of the riparian or streambank zones.

Roads and/or railroad grades have impacted wetlands and other components of all core areas, intercepted and channelized runoff and groundwater, prevented wood from reaching the channel, caused channel constrictions at crossings, increased sedimentation, and degraded floodplain functions. In the upper watersheds these impacts degrade spawning and rearing habitat. In lower rivers and tributaries, these impacts can affect water temperature and coldwater refugia, likely important factors for bull trout foraging, migrating, and holding during the summer.

Improperly sized or located culverts are a significant legacy of roads in all core areas except Elwha. The Washington State Conservation Commission limiting factors and watershed resources inventory identifies many problem culverts, as well as other impacts to salmonid habitat, related to roads and road construction (WSCC 1999; 2000a,b; 2001). Culverts are also discussed in “Isolation and Fragmentation” under the “Reasons for Decline” section.

Skokomish Core Area. There are approximately 750 kilometers (470 miles) of State, Federal, County, and private roads within the watershed (USDA 1995b). The road density by subwatershed ranges from 3.7 kilometers of road per square kilometer (6.0 miles per square mile) to fewer than 1.5 kilometers of road per square kilometer (2.5 miles per square mile). Roads have changed hydrologic flow patterns in the Skokomish watershed, resulting in significant mass wasting of soil and vegetation.

Results of the South Fork Skokomish River Watershed Analysis indicate a significant impairment of aquatic habitat within the core area due to extensive vegetation removal and road construction (USDA 1995b). Of the 21 subbasins identified, 16 exceeded the road density criteria of 1.5 kilometers per square kilometer (2.5 miles per square mile) (USDA 1995b). Of these, 13 have densities greater than 1.9 kilometers per square kilometer (3.0 miles per square mile) of subbasin. Areas with high road densities include much of the South Fork Skokomish River and Purdy, Vance, Rock, LeBar, and Cedar Creeks (WSCC 2003).

Some road decommissioning occurred prior to the 1995 South Fork Skokomish River Watershed Analysis, and road decommissioning continues to be high priority action for the Olympic National Forest. For example, Brown Creek road decommissioning has removed all spur roads, and a total of 14.4 to 16 kilometers (9 to 10 miles) of road have been decommissioned. In 1995 there were 280 road crossings in the Vance Creek watershed. The U.S. Forest Service has decommissioned numerous roads since 1995 and this number has likely been reduced. New logging roads on private lands are still being constructed (WSCC 2003).

Approximately 2,500 existing erosion sites have been identified with the Skokomish core area (USDA 1995a). These sites range in size from 0.1 to 2 hectares (0.25 to 5 acres). Ninety percent of all inventoried sites are associated with roads; the other 10 percent are stream bank or timber harvest unit slope failures. Sixty-five percent of all sites affect the aquatic system (USDA 1995a). Less than 5 percent of the sites are associated with mass wasting events; the majority of sites are the result of surface erosion. During the winter of 1994, storm events along road systems in the upper watershed resulted in 15 mass wasting events.

Quinault Core Area. Within Olympic National Park, road access extends to the Graves Creek Guard Station at river mile 53.5 and the North Fork Ranger Station, approximately 4.8 kilometers (3.0 miles) upstream from the confluence of Graves Creek and the North Fork Quinault River. Although bridges are used for major crossings, smaller tributaries and intermittent channels pass through culverts that may block passage for juvenile bull trout. Maintenance of the North Fork and Graves Creek roads has led to streambank destabilizations, loss of riparian and floodplain function, and possible impacts to potential bull trout spawning and rearing habitat.

A 1996 survey of road-related bank stabilization in the Olympic National Park identified 246 meters (820 feet) of armoring along the North Shore Road, 652 meters (2,172 feet, or 0.4 miles) of armoring along a 3.2-kilometer (2-mile) stretch of Graves Creek Road, 661 meters (2,202 feet) of bank protection on the South Shore Road, 738 meters (2,461 feet) of revetments[†] on the North Shore Road, and 148 meters (492 feet) of armoring at the Quinault Bridge for a total of 2.5 kilometers (1.55 miles) (WSCC 2001). This figure does not take into account additional bank protection on private lands between Lake Quinault and the bridge at Cannings Creek. The area upstream from Lake Quinault has experienced several channel changes and road washouts over the past 20 years. Because of the increase in bank protection measures along both sides of the mainstem, this section of the upper watershed was rated as “poor” for floodplain functions and riparian conditions. The watershed analysis (Quinault Indian Nation and USDA 1999) identified several roads within the watershed as high priority for restoration, including Graves Creek and the North Fork Roads in the park, the North and South Shore Roads upstream from Lake Quinault, midslope roads on

Quinault Ridge, roads on Canoe and Prairie Creeks, and old railroad grades and abandoned logging roads in the lower watershed.

Although culvert inventories are incomplete, the current database identified stream crossings in Higley, Slide, McCalla (Highway 101), and McCormick Creeks where culverts needed repairs or presented fish passage problems (WSCC 2001). Several culverts on Gatton Creek, the South Shore Road, July Creek, and at the Rainforest Resort have also been identified as being potential fish barriers (WSCC 2001). The extent to which these streams are used by bull trout is unknown, although these streams could provide access for other salmonids.

Queets Core Area. The upper Queets River watershed upstream from the confluence with the Sams River is roadless and considered to be in pristine condition. However, the Queets River Road parallels the mainstem from the Queets River Campground at river mile 23 to the Highway 101 bridge. Because the corridor is not very wide, road densities in the floodplain are 1.5 kilometers per square kilometers (2.5 miles per square mile). Even though the Queets River Road is located on the terrace or toe slope[†] for much of the way, impacts to the river have occurred. A major problem area has been identified west of the Matheny Creek bridge where the road traverses an unstable slope (WSCC 2001). The hillside is composed primarily of glacial clay that causes turbidity in the river during heavy rains or whenever road maintenance activities are conducted in that area. Other than two bridge crossings, there are no roads in the floodplain downstream from river mile 10.

Road densities in the lower and upper Clearwater River are 2.3 and 2.0 kilometers per square kilometer (3.7 and 3.2 miles per square mile), respectively (WSCC 2001). These high road densities suggest a large number of stream crossings. Fish passage problems likely occur at many stream crossings, and the risk of road sediment input is high, particularly on midslope roads where side-cast construction methods were used. Several large road-related debris torrents were documented in the Snahapish River, Suzie Creek, and Sollecks River watersheds in recent years. These events affected both the streams of origin as well as the Clearwater River, and impacted fish habitat and salmonid populations for many years. The watershed analysis (USDA 1995a) identified several midslope and steep switchback roads in areas with high potential for mass wasting, including many with undersized culverts and deep and unstable fills. Roads identified as needing repair or decommissioning on Washington Department of Natural Resources and U.S. Forest Service lands in the Matheny Creek and Clearwater River drainages include the West Boundary Road, Queets Ridge, old log stringer bridges in the Stequaleho drainage, two stream crossings on the Hoh-Clearwater mainline at Donkey and Iskrah Creeks (tributaries to Shale Creek), and several old logging roads in the Salmon River watershed. However, the current status of these roads is unknown.

The watershed analysis (USDA 1995a) noted that, for roads located in the floodplain, lack of routine maintenance (especially culvert cleaning), improper drainage systems, and management-related mass wasting events cause chronic degradation of fish habitat and contribute to the loss of off-channel rearing habitat. Aerial photo interpretation and data analysis indicated that 56 percent of the landslides in Matheny Creek were road related, and 44 percent originated within timber harvest units. In the Salmon River drainage, 51 percent of the landslides were caused by timber harvest activities, and 25 percent were related to road failures (Quinault Indian Nation 2000).

Road information is relatively complete for the Salmon River, and surveys indicate that none of the culverts currently present a fish passage barrier (Quinault Indian Nation 2000). The watershed analysis (USDA 1995a, 1997) identified potential road-related problems in the Clearwater subbasin, Sams and Salmon River watersheds, on Kostly and Tacoma Creeks, Hook Branch, and the Lower, Middle, and South Forks of Matheny Creek.

Hoh Core Area. Riparian roads in the Hoh River basin have impacted both instream and floodplain habitat. Some of these roads closely parallel the streams, acting as dikes, disconnecting potential off-channel habitat, and increasing sediment to streams (WSCC 2000b). Some of the most heavily impacted streams include Nolan and Owl Creeks and the mainstem Hoh River. The volume of fine sediment transported from precipitation runoff is directly related to road density. In the Hoh basin, road density also correlates to an increase in debris flows within the basin, and the density of midslope roads correlates with increases in peak flows.

Date: XXXXXXXXXXXXXXXXXXXXXXXXXXXX

Improperly sized or located culverts block fish access in several streams within the Hoh core area. These streams include Dismal, Nolan, Braden, Canyon, Cassel Creeks and several unnamed tributaries to the Hoh River (WSCC 2000b).

The Upper Hoh Road provides the primary access to Olympic National Park and contains miles of riprap[†] for bank armoring. The road constricts the river and has been washed out several times as the river abandoned one channel while moving to create a new route or channel. As the road is rebuilt, additional bank armoring has been added to the river in an attempt to stabilize the road. The large boulders used for armoring prevent channel migration and formation of new habitats, create unnatural meander patterns, and disconnect the mainstem from off-channel habitats and adjacent riparian forest.

As of August 2000, the estimated amount of riprap along the Hoh River from the Hoh campground (river mile 33) to the mouth was approximately 4,737 meters (15,542 feet), with 3,055 meters (10,023 feet) located outside Olympic National Park and 1,682 meters (5,518 feet) located inside Olympic National Park. However, a greater proportion of the Hoh River is hardened inside Olympic National Park (17.0 percent) than outside of the Park (6.3 percent) (Brenkman, *in litt.* 2003a).

Dungeness Core Area. Forest road management has been a major concern in the Dungeness core area. Roads in this core area have increased both the potential for mass wasting (*i.e.*, failure of side-cast road construction material, failure resulting from concentrated or blocked drainage across roads) and the amount of fine sediment delivered to the stream channel. In 1949, there were only 13.3 kilometers (8.3 miles) of logging roads constructed on U.S. Forest Service lands in the Dungeness watershed. By 1983 the road mileage had increased by a factor of 10, with a doubling of road mileage between 1965 and 1983 (WSCC 2000a).

Of the 24 subbasins within the Dungeness River watershed, 16 exceed the 1.5 kilometers per square kilometer (2.5 miles per square mile) threshold for watershed condition analysis as established by the Olympic National Forest (USDA 1995c). Twelve of the 16 subbasins are located in lower elevation watersheds where significant rural and urban development has occurred. Much of the stream bank and riparian effects associated with that development have been identified in “Residential Development and Forest Management” under the “Reasons for Decline” section. Four subbasins occur at the mid-level elevation zone between the rural and urban development and the forested lands within the Olympic National Park and U.S. Forest Service wilderness areas: Pats, Caraco, and Gold Creeks and the Middle Dungeness River. These four subbasins were historically managed for extensive timber production (USDA 1995c), and Gold and Caraco Creeks also exceeded the road density threshold within the riparian area. Most of the road construction within the middle elevation subbasins (up to the Olympic National Park and wilderness boundaries) was related to timber harvest (USDA 1995c). Extensive slope failures and slides associated with unstable geology and road construction have occurred along Gold and Silver Creeks.

A very high rate of road failure on U.S. Forest Service land occurred following the winter of 1998 to 1999. This is particularly evident on U.S. Forest Service Roads 2860, 2870, and 2880 (WSCC 2000a). Extensive mass wasting associated with these roads has occurred, and there is concern about the potential for future mass wasting.

In an analysis of floodplain modifications in the lower Dungeness River (downstream from river mile 10.8) several channel constrictions associated with bridges were identified (WSCC 2000a). Channel and floodplain constrictions exist at Ward Bridge; channel constrictions occur at old Olympic Highway and Railroad Bridges; and bedload transport is restricted by Highway 101 bridge piers and openings.

Residential Development and Urbanization (Factor A)

Overview. Residential development and urbanization have occurred within portions of several core areas, including the Dungeness, Skokomish, and to a lesser extent, the Elwha core areas. Greatest impacts have been to lower river channels and estuarine and nearshore marine habitats. Where these habitats remain intact, residential development continues to pose a threat. These habitats are important to anadromous bull trout for foraging and migration. Significant portions of nearshore habitat in Hood Canal and the Strait of Juan de Fuca have been altered by bulkheads placed to protect various developments. Stormwater runoff from residential development and urbanization contributes to nonpoint source water pollution from the transport of toxic metals and organic contaminants, such as petroleum hydrocarbons. Other sources of toxic contaminants are discharges of municipal and industrial wastewater, pesticide runoff from residential lands, leaching contaminants from shoreline structures (*i.e.*, treated wood), and channel dredging. Land clearing and impervious surfaces alter the hydrologic regime. Channelization and the construction of dikes and levees have altered lower river channels in several core areas. These activities have simplified once complex stream channels, degrading important foraging, migration, and overwintering habitat for bull trout and their prey base.

Anadromous bull trout use marine habitats for foraging and growth and seasonally may enter marine waters to prey on surf smelt or Pacific herring where they school or spawn (Kraemer 1994). These species depend on the nearshore marine environment and spawn in the intertidal or shallow subtidal waters at specific locations (WDFW 2000). These locations are very vulnerable to destruction or modification through human activities, especially urban and rural development. Techniques have not been developed to mitigate for or replace spawning habitat modified or destroyed by human activities.

Forage fish, bottom fish, and wild salmon have declined in the Puget Sound (PSWQAT 2000). Part of this decline has been attributed to human encroachment and development of the nearshore areas throughout Hood Canal and the Strait of Juan de Fuca that has resulted in the loss of nearshore[3] habitat. It is likely that anadromous bull trout have been impacted by the decline in forage base and loss of habitat in this marine environment.

Many historical floodplain areas that were originally diked and drained for agricultural use have been or are now being converted to residential and industrial

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[3] Nearshore habitat (20 meters [65 feet] below the mean low water mark to 61 meters [200 feet] upland of the ordinary highwater mark) generally includes several of the following habitats: bluffs, beaches, marshes, riparian vegetation, sandflats, mudflats, rock and gravel habitats, unvegetated subtidal areas, kelp beds, intertidal algae, and eelgrass beds (PSWQAT 2000).

developments. The effects of dikes, levees, and other flood control actions on bull trout habitat are discussed in “Agriculture” under the “Reasons For Decline” section.

Skokomish Core Area. Along with agricultural development in the Skokomish River Valley, residential development has resulted in conversion of forest land and construction of roads, levees, and bank protection. About 1,093 hectares (2,700 acres) of the Skokomish River floodplain have been converted to residential or agricultural uses (USDA 1995b). Most residential and recreational development around Lake Cushman occurs on the west side of the lake. All businesses and residences have individual septic systems, often in close proximity to the lake. However, the effects on water quality in Lake Cushman from this development is unknown.

Floodway mapping indicates that the entire Skokomish Valley is within the 100-year floodplain of the Skokomish River (Federal Energy Regulatory Agency 1996). In addition, a rain-on-snow event large enough to cause flooding occurs in the Skokomish Valley at least once a year (USDA 1995b). In an attempt to reduce or prevent property damage from flooding, levees have been constructed along the river. Levee construction has contributed to raising the river channel bottom. Levee construction using gravel material excavated from the river channel leaves the levees highly vulnerable to failure. Erosion control projects have also been implemented to maintain the Skokomish River within defined areas to reduce the loss of property. These dikes, levees, and bank protection projects have also contributed to the loss of ecological function in the Skokomish River estuary by concentrating stream flows and sediment that normally would pass through productive zones of the adjacent surge and tide planes (USDA 1995b).

Quinault Core Area. Residential developments in the Quinault core area are limited to the communities of Quinault and Amanda Park on the south shore of Lake Quinault and the Tribal community of Taholah at the mouth of the river. Although some concern for water quality related to waste water and the proximity of aging septic systems to the shoreline around Lake Quinault have been raised, development is not considered to be a significant impact to bull trout in the Quinault core area.

Queets Core Area. The small communities of Queets, Clearwater, and Kalaloch include the majority of the residential and commercial developments in this watershed. Because the Queets River area is very sparsely populated, impacts from residential development are considered minor in this core area.

Elwha Core Area. The upper Elwha River is within Olympic National Park and has not been impacted by residential and urban development; impacts from these activities are found mainly in the lower Elwha River. Concurrent with residential development, the lower Elwha River floodplain has been altered and encroached upon by the construction of dikes. Dikes have been constructed in locations on the lower Elwha River, including the Lower Elwha S'Klallam Tribe's reservation at river mile 3.5, to protect the City of Port Angeles industrial water pipeline and on the west side of the estuary to protect homes (WSCC 2000a). These dikes have not only constricted the channel but have severely impacted nearshore and estuary habitat and processes.

The City of Port Angeles maintains water rights on the Elwha River and Morse Creek. In 1927, the city obtained rights to 150 cubic feet per second of water, a substantial withdrawal from the river. In 1974, through a change in the use permit, 50 of the 150 cubic feet per second were appropriated for salmon rearing by Washington Department of Fish and Wildlife.

Dungeness Core Area. Port Angeles is a major urban area with associated residential development in the Dungeness core area. In 1991, urban areas were estimated to total 166 hectares (410 acres). However, these figures are thought to significantly underestimate the actual area currently encompassed due to significant urban and suburban development since that time (WSCC 2000a). Increased stormwater due to forest and agricultural conversion (loss of vegetative ground cover) and urbanization (culverts, ditches, and impervious surfaces) has contributed to degradation of water quality in the lower Dungeness River and associated tributaries.

Extensive urban and rural development occurring in the lower Dungeness and tributaries has resulted in a proliferation of shallow groundwater wells. There is a high likelihood that these wells are continuous with surface water flows in the lower watershed and are affected by groundwater return flows from irrigation in the watershed (WSCC 2000a).

Rural residential areas include 3,960 housing units broken down into two densities, high (less than 0.6 hectares [1.5 acres] per housing unit) and low (0.6 to 2 hectares [1.5 to 5 acres] per housing unit) (WSCC 2000a). Much of the current rural residential development in the watershed is supported by septic tanks. Approximately 82 percent of the soils within the watershed have severe limitations for on-site septic use (WSCC 2000a).

In the Dungeness core area, flood and erosion control, channelizing, and bedload aggradation are linked to a combination of factors, including agriculture and residential and urban development. Effects from these actions are described in "Agriculture" in the "Reasons for Decline" section.

Loss of eelgrass in the intertidal or shallow area is a key nearshore habitat concern. Eelgrass provides valuable habitat for a variety of marine species important to bull trout for prey base, including rearing juvenile salmonids and spawning herring (O'Toole *et al.* 2000). To accommodate residential and urban development it is likely that extensive eelgrass meadows have been eliminated with filling of intertidal areas, bank armoring, and modifications of shoreline morphology.

Hood Canal Foraging, Migration, and Overwintering Habitat. Hood Canal is a relatively narrow bay with a shallow sill near its entrance, making it sensitive to pollution. Based on water quality monitoring data, southern Hood Canal was identified by the Washington Department of Ecology as an area of "very high concern" for very low dissolved oxygen and for limiting concentrations of nitrogen in dissolved nutrients (WDOE, *in litt*. 2001). During the late 1960's, human population growth and development in the Hood Canal region, particularly along the shorelines, began to increase dramatically. Many areas along the canal have violated water quality standards established by Washington State and the U.S. Environmental Protection Agency. Poor water quality in Hood Canal is primarily due to impacts from nonpoint source pollution (Hood Canal Technical Work Group 1995). This pollution includes bacterial, nutrient, sediment, and chemical contamination. Most of these contaminants are transported to Hood Canal via stormwater runoff. Surf smelt, Pacific herring, and Pacific sand lance, all significant prey items for anadromous bull trout, depend on the nearshore marine environment. These forage fish in Hood Canal exist in an increasingly urbanized and threatened environment (O'Toole *et al*. 2000).

The abundance of chum salmon fry, another significant prey species, has been positively correlated with the size of shallow nearshore zones in Hood Canal (Bax *et al*. 1978), and sublittoral[†] eelgrass beds have been considered to be the principal habitat used by juvenile chum salmon in Hood Canal (Simenstad *et al*. 1980). Shoreline and in-water construction, channelization, and other human actions along the shoreline degrade and destroy kelp and eelgrass beds, salt marshes, mud flats, and other nearshore habitats. Marine shoreline bulkheading and boat docks have impacted nearshore shallow habitat and riparian vegetation along Hood Canal.

Strait of Juan de Fuca Foraging, Migration, and Overwintering Habitat. Impacts from development in tributaries to the Strait of Juan de Fuca have resulted in significant habitat loss for anadromous salmonids. Morse Creek, a smaller watershed between the Dungeness and Elwha Rivers, was a significant producer of several species of salmon. As discussed earlier, anadromous salmonids provide an important seasonal prey base for bull trout. The Morse Creek channel has been altered by development, channelization, and forest practices. Floodplain function has been severely altered by constrictions resulting from diking, development encroachment, and transportation corridors. Historical estuary conditions, thought to be in large part responsible for Morse Creek's productivity, have been basically eliminated by development; however, Morse Creek habitat within the Olympic National Park boundary is in excellent condition (WSCC 2000a). Habitat outside of Olympic National Park has been significantly impacted by suburban development.

Siebert and Ennis Creeks also drain directly to the Strait of Juan de Fuca. The lower portions of these streams are relatively intact, but habitat in upper portions are adversely affected by recent rural development, agricultural practices, and forest practices. The marine shoreline is armored from the mouth of Morse Creek west through Port Angeles to the end of Ediz Hook at the mouth of the Elwha River. This armoring effectively eliminates most, if not all, natural nearshore habitat function (WSCC 2000a). The nearshore environment provides important habitat for bull trout prey species, including spawning surf smelt, herring, and salmon smolts.

Streams that have their headwaters in the foothills, such as Bell and Siebert Creeks (and other streams draining into the Strait of Juan de Fuca) are subject to hydrologic/stormwater effects as a result of the permanent loss of forest cover due to conversion to residential development and from forestry activities. During severe rain storms or rain-on-snow events this has resulted in increased erosion in the small headwater streams as well as increased stream power to transport sediment and erode streambanks lower in the system (WSCC 2000a).

Fisheries Management

Overview. All core areas in the Olympic Peninsula Management Unit have experienced both current and historical impacts to bull trout from fisheries management. The Olympic Peninsula Recovery Team identified incidental mortality to bull trout associated with recreational and Tribal harvest of other salmonids as both historically and currently one of the most important factors causing the decline in abundance of bull trout. In the 1992 Draft Bull Trout/Dolly Varden Management and Recovery Plan, the Washington Department of Wildlife identified increased fishing pressure as a major contributor to char mortality (WDW 1992). Recreational and Tribal salmon and steelhead fishing are likely still significantly impacting bull trout in coastal rivers. Other fisheries management activities that have both long-term historical and current impacts on bull trout populations include fish stocking, hatchery operations, and, indirectly, other fisheries management that affects the bull trout prey base (*e.g.*, baitfish and salmon).

The piscivorous diet of anadromous, fluvial, and adfluvial bull trout makes them susceptible to fluctuations in the densities of other fish populations. Ratliff and Howell (1992) found that abundance of bull trout in several watersheds declined as salmon declined. Several stocks of salmon have been listed as threatened under the Endangered Species Act in streams on the Olympic Peninsula. Historically, these rivers sustained much larger populations of anadromous fish. There are numerous current programs and management actions underway to recover listed and depressed anadromous salmon stocks. These actions will assist bull trout recovery by increasing prey abundance.

Recreational Fisheries (Factor B). Historically, size and bag limits for recreational sport fishing seasons on the Olympic Peninsula were the same for trout and char. Because Dolly Varden and bull trout are difficult to distinguish from each other in the field, the Washington Department of Fish and Wildlife manages the two species as "native char." Seasons and limits for "native char" within Olympic National Park were also essentially the same as surrounding State-managed waters until recent years. The Washington Department of Fish and Wildlife and Olympic National Park closed all rivers on the Olympic Peninsula to fishing for Dolly Varden/bull trout in 1994. Tribal waters on the Queets River, Quinault River, and Lake Quinault remained open until 1999. Prior to 1994, recreational seasons for char in the lower mainstem areas of the larger rivers were open from 9 to 11 months of the year and for just over 5 months, from late May through October, in the upper reaches and most tributaries. Generalized limits on char in most waters of the Olympic Peninsula included:

Years	Limits on char caught in Olympic Peninsula
1965–1970	12 trout and char with total weight restrictions
1971–1980	8 trout and char with total weight restrictions
1981–1991	8 trout and char with length restrictions
1992–1993	2 char, at least 20 inches or more
1994–present	Closed to fishing for char

The impacts of these seasons and limits on bull trout populations are largely unknown, as char were not the target of most recreational anglers and were only caught incidentally to salmon, steelhead, and trout. However, based on our current understanding of the age and growth of bull trout on the Olympic Peninsula, the historical regulations were probably too liberal. Since bull trout are long-lived, grow slowly, and mature later than trout, past size and bag limits may have contributed to their decline. The management approach currently in use by a number of fish and wildlife management agencies sets bag limits based on spawner/recruitment relationships for the target species. Where these data are lacking, conservative bag limits are adopted in combination with a minimum size that corresponds with the size at maturity, theoretically allowing fish to spawn at least once before becoming vulnerable to harvest.

In some instances, where anglers targeted bull trout, recreational fishing appears to have had some significant impacts on population size and viability. The char in Lake Cushman and the North Fork Skokomish River were widely recognized for producing large trophy-sized individuals, some of which exceeded 4.5 kilograms (10 pounds) (McLeod 1944). Anglers targeted these fish in Lake Cushman and on the fall spawning migration in the North Fork Skokomish River. It is widely believed that the recreational fishery in the reservoir and North Fork Skokomish River was primarily responsible for a significant decline in the spawning escapement[†] from 1972 to 1980 (Figure 9), although operation of the Tacoma Power hydropower projects has also impacted all fish populations in the Skokomish watershed. During the period of decline, the limit on trout and char in the North Fork Skokomish River upstream from Lake Cushman was eight fish or 2.7 kilograms (6 pounds) total plus one fish. Beginning in 1980, all fishing in the North Fork Skokomish River was closed during bull trout migration and spawning (the Olympic National Park boundary to Dolly Pool), and in 1982 the area was closed to all fishing for char. In 1986, harvest of char in Lake Cushman was closed (WDFW 1998). These restrictions appear to have resulted in a delayed (6 years), although short-term (10 years), recovery of the North Fork Skokomish bull trout population (Figure 9). Determining the cause of the more recent decline of this population is a high priority research need for the Olympic Peninsula Management Unit.

The 1994 fishing closures likely had a positive influence on the abundance of this species within the Olympic Peninsula and throughout Washington in general. It is assumed that bull trout mortalities associated with incidental catch during other recreational fisheries since 1994 has been much lower than when bull trout were targeted for harvest. However, very little is known about the extent of incidental moralities of bull trout associated with recreational fisheries of salmon and steelhead stocks on the Olympic Peninsula. Currently, there is very limited monitoring of Olympic Peninsula recreational fisheries and incidental number of bull trout caught and released (Appendix 1).

For recreational fisheries the incidental catch of bull trout usually occurs during general “trout” and salmon fisheries and, in particular, during the early portion of winter steelhead fisheries. As more restrictive salmon fishing regulations have been adopted for Puget Sound rivers, salmon sport fishing effort on coastal rivers, such as the Hoh and Queets Rivers, has steadily increased (B. Freymond, pers. comm. 2003). Increased fishing pressure can become a major contributor to bull trout mortality (Brown 1994).

Incidental hooking of bull trout has been documented in major coastal rivers. Bull trout are apex predators and are especially susceptible to incidental hooking during other targeted fisheries. In fact, biologists have found hook-and-line fishing to be one of the most successful tools for population sampling of bull trout (Brown 1994). For salmonids in general, incidental hooking mortality varies from less than 5 percent to 24 percent for fish caught on artificial lures, and between 16 percent and 58 percent for bait-caught fish (Taylor and White 1992; Pauley and Thomas 1993; Lee and Bergersen 1996; Schill 1996; Schill and Scarpella 1997). During the mid- to late-summer period of staging, bull trout pre-spawning aggregations are especially susceptible to this incidental hooking (Brown 1994). In the Skokomish core area the consequences of continued Chinook salmon harvest in Lake Cushman, and the incidental catch of bull trout associated with that harvest, may significantly impact the low number of both Chinook salmon and bull trout in Lake Cushman and the Upper North Fork Skokomish River (Young, *in litt.* 2003).

Tribal Fisheries (Factor B). Bull trout are susceptible to incidental mortality associated with gill-net fisheries that target salmon and steelhead at the mouths of the Dungeness, Elwha, Hoh, Queets, and Quinault Rivers. Currently there is no monitoring of bull trout bycatch[†] in the gill-net fisheries. The extent and seasonal variation of mortality remains unknown in each river, but it is believed to be a significant contributor to mortality of bull trout in several Olympic Peninsula rivers. It is likely that gill-net fisheries are size-selective for large adult bull trout based on the mesh sizes used in each river. In 2002, biologists obtained 108 adult bull trout specimens incidentally captured in net fisheries occurring from January to June 2002 in an Olympic Peninsula coastal river (Brenkman and Corbett, *in litt.* 2003a). These bull trout, ranging in size from 290 to 760 millimeters (11 to 30 inches) with an average size of 580 millimeters (23 inches), were captured in winter steelhead fisheries (net mesh size 10 to 15 centimeters [4 to 6 inches]) and spring and summer Chinook salmon fisheries.

Many of the unique life history attributes of bull trout increase their susceptibility to capture in gill-net fisheries in these coastal rivers. The highly migratory behavior of bull trout, coupled with their longevity and ability to repeat spawn, increases the number of possible encounters with nets located at river mouths. Capture may occur during upstream or downstream movements to and from saltwater habitats. Relative gill-netting effort at river mouths or estuaries varies from river to river (Table 4).

Table 4. Relative gill-netting effort at river mouths or estuaries with gill-net fisheries based on available data.

River System	Fishery	Days Open[1]	Time Span	Contact
Dungeness	Coho salmon	42	09/15/02 to 11/07/02	Jamestown S'Klallam Tribe
	Steelhead	32	12/01/02 to 01/30/03	
Quinault	Winter steelhead	90[2]	11/04/02 to 05/04/03	K. Hughes, WDFW, and the Quinault Indian Nation
	Sockeye salmon	0	04/01/02 to 06/30/02	
	Summer Chinook	14	07/01/02 to 07/31/02	
	Fall Chinook	22	08/01/02 to 09/05/02	
	Fall coho salmon	30	06/16/02 to 10/31/02	
Skokomish	Chinook salmon	32	08/04/02 to 09/25/02	M. Ereth
	Chum salmon	15	11/17/02 to 12/07/02	
	Coho salmon	35	09/29/02 to 10/31/02	Skokomish Tribe
	Steelhead	6	12/23/02 to 02/15/03	
Hoh	Winter steelhead	35	12/03/01 to 04/01/02	B. Freymond, WDFW, and the Hoh Tribe
	Spring Chinook salmon	17	05/06/02 to 08/26/02	
	Fall coho salmon	39	09/01/02 to 012/1/02	
Queets	Winter steelhead	40	11/24/02 to 04/26/03	B. Freymond, WDFW, and the Quinault Indian Nation
	Fall steelhead	45	09/01/02 to 11/23/02	
	Summer Chinook salmon	1	05/06/01 to 08/25/01	
Humptulips	Fall steelhead	9	09/15/01 to 10/14/01	K. Hughes, and the Quinault Indian Nation
	Winter steelhead	23	12/01/01 to 12/30/01	
Elwha	Fall coho salmon	24	09/19/02 to 11/17/02	D. Morrill
	Winter steelhead	40	12/28/02 to 02/15/03	

[1] 1 day = 24 hour continuous period.
[2] Tribal gill-net fishery occurs in lower 13 kilometers (8 miles) of the river.

Nonnative species (Factor E). Nonnative fish stocking may negatively impact bull trout through competition and/or predation. Brook trout pose an additional threat to bull trout through the potential for hybridization (Markle 1992). Both the Dungeness and Elwha River basins were identified by Mongillo and Hallock (1993) as having fairly extensive brook trout populations. However, brook trout stocking has primarily occurred in high lakes, and the recovery team determined the extent of impacts to bull trout from this high lake stocking is largely unknown on the Olympic Peninsula. One area of concern is the South Fork Skokomish River where a bull trout × brook trout hybrid was captured (Olympic Peninsula Recovery Team, *in litt.* 2003a).

Hatcheries (Factor E). All of the core areas have hatchery releases of at least one species of anadromous salmon, steelhead, or cutthroat trout. Interaction between bull trout and these hatchery fish has not been examined. Although bull trout evolved with and continue to coexist with anadromous salmon, steelhead, and cutthroat trout, hatchery releases of certain salmonids may impose predation and competition pressures on bull trout above natural levels. In Lake Cushman in the Skokomish core area, 3.3 million rainbow trout were planted from 1935 to 1986, 31 million Kokanee salmon were planted from 1936 to 2001, and 3.6 million cutthroat trout were planted from 1952 to 2001. While these releases may provide an enhanced prey base for bull trout, they likely also impose predation and competition pressures. Further hatchery planting of fall-spawning salmonids is being considered for Lake Cushman. This has the potential to impact the already limited spawning habitat available to bull trout in the North Fork Skokomish River upstream from Lake Cushman. Other potential impacts from hatcheries include diversions of water, unscreened ditches, barriers, hatchery effluent discharge, low dissolved oxygen, and disease control chemicals.

In the Quinault core area, operations at the Quinault National Fish Hatchery divert approximately 10 to 50 percent of the flow from the channel, depending on the season. The electronic weir at the hatchery currently impedes migration to 54 kilometers (33 miles) of anadromous fish habitat and precludes use of most of the watershed by bull trout. Discussions are underway to address this issue and facilitate upstream passage of bull trout from May to mid-September. Although the risk is relatively small, bull trout may be trapped upstream from the weir if they use the bypass channel[†] or move upstream when the current is turned off. Adult or subadult bull trout that attempt to move through the electric field may be injured or killed, while those entering the fish handling facility may be harmed.

In the Dungeness core area, the Washington Department of Fish and Wildlife hatchery fish collection rack blocks migration of fish at certain times of the year. In addition, a poorly screened hatchery water intake is a complete barrier to upstream fish passage in Canyon Creek (WSCC 2003). The Washington Department of Fish and Wildlife currently has funds allotted to engineer and construct modifications to the dam for fish passage, or to restore physical and biological processes by removal of the dam (WSCC 2003).

Forage (Prey) Base (Factor E). Bull trout migrations and life history strategies are closely related to their feeding and foraging strategies. In the Pacific Northwest, these strategies were historically connected with, and most likely dependent upon, healthy salmon populations (Baxter and Torgersen, *in litt.* 2003; Armstrong and Morrow 1980; Brown 1994; Nelson and Caverhill 1999). Food resources provided by salmon include dislodged eggs, emergent and migrating fry, smolts, and flesh from decomposing carcasses. Recent studies have documented low abundances and declines of Pacific salmon throughout much of their range (NMFS 1991; Washington Department of Fisheries *et al*. 1993). In 1991, the American Fisheries Society published a list of 214 naturally spawning stocks of salmon, steelhead, and cutthroat trout from California, Oregon, Idaho, and Washington, including 101 stocks at high risk of extinction, 58 stocks at moderate risk of extinction, 54 stocks of special concern, and one stock classified as threatened under the Endangered Species Act (Nehlsen *et al.*1991). Vigorous populations of migratory bull trout require abundant fish forage, and it is likely that many bull trout populations have been affected by the documented declines in salmon populations. For example, in several river basins where bull trout evolved with large populations of juvenile salmon, bull trout abundance declined when salmon declined (Ratliff and Howell 1992; Rieman and McIntyre 1993). The declines of salmon and steelhead are the result of a number of factors including habitat loss and migration barriers as well as fisheries management.

Overall, current salmon and steelhead populations are estimated to be at half of historical levels, even with hatchery production. Native stocks of concern include sea-run cutthroat (*Onchorynchus clarki clarki*) and sockeye salmon. Adult returns of sockeye salmon in particular have declined significantly over the past century. In Lake Quinault, the sockeye population has declined from around 251,000 in 1917 to just under 53,000 returning adults in 1999. The steady drop in population and loss of carcasses from spawned-out fish has resulted in a decline in the nutrient and zooplankton (microscopic animals floating in the water that are used for food by nearly all aquatic animals) levels in the lake (Quinault Indian Nation and USDA 1999). Artificial nutrient enhancement to increase sockeye salmon production is being considered for the lake. Impacts to bull trout or prey species from this type of enhancement are unknown.

Habitat (Factor A). From the 1950's to 1970's fisheries managers promoted the removal of large woody debris and logjams from streams because they were believed to hinder fish migration (Murphy 1995). This practice eliminated or greatly reduced the habitat complexity in many streams. Although removal of wood from streams has been discontinued, legacy effects are still apparent throughout streams on the Olympic Peninsula.

Habitat Fragmentation and Isolation (Factor A)

The Salmon and Steelhead Habitat Limiting Factors Resource Inventory (WSCC 1999; 2000a,b; 2001) identifies numerous impassible barriers to migratory fish in the Olympic Peninsula Management Unit. Improperly installed or sized and failed culverts have been identified as barriers to fish movement and migration throughout the Olympic Peninsula (see the “Forest Management” and “Transportation Networks” sections). In the Hoh core area, historical cedar salvage practices have resulted in a legacy of cedar spalt debris forming impassable barriers in coastal rivers and streams. In the Dungeness core area construction of flood control structures, water diversion structures, and irrigation withdrawals resulting in barriers, higher temperatures, and low flows have also contributed to the degradation and fragmentation of migratory corridors.

Tribes in Washington are currently involved in a lawsuit against the State of Washington regarding improperly functioning culverts. Depending on the resolution of this case, there could be benefits to migratory bull trout if culverts currently impacting passage for bull trout are included as culverts prioritized for correction.

In the Hoh, Skokomish, Quinault, and Dungeness core areas, migratory corridors have been altered through physical reductions of stream channel depths and reductions of cover habitat along with flow regime alterations in the mid- to lower subbasins. Large woody debris recruitment from adjacent riparian reserve zones has declined due to human activity related to timber harvest and road construction, along with woody debris removal from lower subbasin stream channels. Reduced amounts of large woody debris instream has minimized holding and rearing areas for adult bull trout during spawning migration and for juveniles during rearing movements among different stream reaches.

The construction and operation of dams has contributed to habitat fragmentation and isolation of bull trout in the Elwha and Skokomish core areas. These dams lack sufficient passage and are barriers to upstream migrants. Impacts from these dams are covered in “Dams” under “Reasons For Decline.”

The hatchery diversion and electronic weir at the Cook Creek National Fish Hatchery have been identified as blocking migration and limiting bull trout use of the upper watershed. At the Washington Department of Fish and Wildlife Dungeness River Hatchery, the adult salmon collection rack across the Dungeness at river mile 10.8 clearly influences migratory fish use of the upper Dungeness and Gray Wolf drainages (WSCC 2001). The small hydroelectric dam on Elk Creek in the North Fork Skokomish River blocks bull trout access. There is potentially suitable spawning habitat in the inaccessible portions of these watersheds.

<u>Disease (Factor C)</u>

In 2003, Olympic National Park biologists observed bull trout in the Hoh River that appeared to have black spot disease (S. Corbett, pers. comm. 2004). Black spot disease is caused by an infestation of one or more species of trematode (Post 1987). The presence of black spot disease may cause mortality, particularly when infestations are heavy. It is uncertain whether black spot disease may be a factor in the decline of bull trout in the Hoh River.

<u>Reasons for Decline: Summary</u>

A summary of the threats to bull trout (reasons for decline) in the six identified core areas of the Olympic Peninsula Management Unit are presented in Table 5; this summary is also presented in narrative form here.

Skokomish Core Area. Historically the Skokomish River produced the largest runs of salmon and steelhead in Hood Canal, most of which were produced in the North Fork Skokomish River. Major impacts to the watershed have resulted from it being primarily managed for hydropower production, timber, and agriculture (WSCC 2003). Rural development has accompanied or followed conversion of agricultural lands and has also impacted aquatic habitat. Alterations to aquatic habitat in the mainstem and South Fork Skokomish River from forestry, roads, agriculture, and rural development include increased sediment, channel aggradation, altered flows, loss of woody debris, and elevated stream temperatures. The South Fork Skokomish River watershed has some of the highest road densities found west of the Cascade Mountains in Washington.

Cushman Dams 1 and 2 on the North Fork Skokomish River were constructed without fish passage and have eliminated connectivity of fish upstream from the dams with habitat and fish in the lower North Fork Skokomish River, the mainstem Skokomish River, the South Fork Skokomish River, and Hood Canal. Lack of, or greatly reduced, flows in the North Fork Skokomish River resulting from diversion of water to a power canal have reduced sediment transport capabilities, resulting in further aggradation of the river. Channelizing and diking for agriculture and residential development have further contributed to sediment accumulation. Incidental mortality to migrating bull trout from Tribal gill-net fisheries has been documented in a coastal river (Brenkman, *in litt.* 2003a) and incidental mortality from other targeted fisheries (both recreational and Tribal) likely also pose a threat to bull trout in the North Fork Skokomish River due to the low numbers of adult fish observed over the past several years.

Dungeness Core Area. Roads, forestry, agriculture, fisheries management, and residential and urban development all pose significant threats to bull trout populations. In the upper Dungeness River watershed, forest roads are thought to be one of the most important causes of habitat degradation due to the inherently unstable geology and steep slopes found within the core area. The road network has increased mass wasting and sediment delivery to streams. Forestry has permanently modified much of the lower watershed, which is now primarily used for farms and homes. Water rights are overappropriated in the Dungeness River and water diversions have altered stream flows, resulting in elevated water temperatures, seasonal migration barriers, and false attractions of bull trout to other streams. Increased storm water from urban and residential development and agricultural practices, including direct animal access to waterways and irrigation diversions, also impact water quality in the Dungeness core area. Incidental mortalities to bull trout from Tribal and recreational fishing are likely impacting bull trout.

Elwha Core Area. Most major threats to the Elwha core area are related to the Elwha and Glines Canyon Dams, which are scheduled for removal in 2007. The two dams have blocked fish migration for nearly 100 years and have eliminated the anadromous life history form from all of the Elwha above the Elwha Dam. The dams have also prevented salmon migration, resulting in the loss of nutrient enrichment from salmon carcasses as well as decreased prey base for most of the river. Further impacts from the dams include elevated water temperatures, loss of spawning gravel recruitment downstream from the dams, and estuarine shoreline erosions resulting from lack of fluvially transported sediment. Other threats to bull trout habitat in the Elwha core area include floodplain modification from dikes and levees built for rural and industrial development and sedimentation from forest practices in Little River, a potential local population. Incidental mortalities to bull trout from Tribal salmon and steelhead gill-net fisheries are likely impacting bull trout.

Hoh Core Area. Timber harvest, extensive road networks, and incidental mortalities to bull trout from Tribal fisheries are significant threats to bull trout populations in this core area. The middle Hoh River and its tributaries have been heavily logged, and many riparian forests have been logged to the stream bank, resulting in elevated stream temperatures and loss of large instream wood. Clear-cut steep slopes within the Hoh River drainage have resulted in mass wasting and channelized landslides. In the Hoh River basin, roads often parallel the streams, acting as dikes and increasing sediment. The Upper Hoh Road has required extensive bank armoring, resulting in decreased stream complexity and disconnecting the stream from off-channel habitat. Incidental mortalities from Tribal salmon and steelhead gill-net fisheries impact migratory bull trout (Brenkman, *in litt.* 2003a).

Queets Core Area. Although the mainstem Queets River is almost entirely within Olympic National Park, significant threats to aquatic habitat in major tributaries of this core area include sedimentation and elevated temperatures from logging and associated road networks. Timber harvest activities occur throughout the Clearwater, Sams, and Salmon Rivers and Matheny Creek, resulting in varying degrees of impacts on the aquatic health of these rivers and associated streams. Road densities in the Clearwater River basin are high, and roads throughout the Queets River basin have been identified as having high potential for mass wasting and needing repair. Gill-net fisheries have been documented to impact anadromous bull trout in an adjacent coastal river, and because fisheries activities and bull trout patterns of use are similar for the coastal rivers, incidental mortalities from Tribal salmon and steelhead gill-net fisheries likely impact migratory anadromous bull trout in the Queets River.

Quinault Core Area. Timber harvest, transportation networks, and potentially incidental mortality to bull trout from other targeted fisheries are the most significant threats to bull trout in this core area. Timber harvest and road construction impacts to bull trout, from both historical and continuing actions, occur in the lower watershed, including some harvest within the floodplain. Gill-net fisheries have been documented to impact anadromous bull trout in another coastal river, and because fisheries activities and bull trout patterns of use are similar for the coastal rivers, incidental mortalities from Tribal salmon and steelhead gill-net fisheries likely impact migratory anadromous bull trout in the Quinault River.

Table 5. Summary of reasons for decline of bull trout in the Olympic Peninsula Management Unit. ("●" indicates a major cause of decline; "○" indicates a relatively minor cause of decline.)

Core Area	Dams	Forest Management Practices	Agriculture	Transportation Networks	Residential and Urban Development	Fisheries Management	Habitat Fragmentation and Isolation
Skokomish	●	●	●	●	●	●	●
Dungeness		●	●	●	●	●	○
Elwha	●	○			○	●	●
Hoh		●		●		●	○
Queets		●		●		●	
Quinault		●		●	○	●	

ONGOING CONSERVATION MEASURES

The overall recovery implementation strategy for the Coastal-Puget Sound Distinct Population Segment is to integrate with ongoing Tribal, State, local, and Federal management and partnership efforts at the watershed or regional scales. This coordination will maximize the opportunity for complementary actions, eliminate redundancy, and make the best use of available resources for bull trout and salmon recovery.

State of Washington

Salmon Recovery Act. The Governor's office in Washington has developed a statewide strategy that describes how State agencies and local governments will work together to address habitat, harvest, hatcheries, and hydropower as they relate to recovery of listed species of salmonids (WGSRO 1999). The Salmon Recovery Act, passed in 1998 (Engrossed Substitute House Bill 2496), provides the structure for salmonid protection and recovery at the local level (counties, cities, and watershed groups).

The Salmon Recovery Act of 1998 directs the Washington State Conservation Commission, in consultation with local governments and treaty Tribes, to invite private, Federal, State, Tribal, and local government personnel with appropriate expertise to convene as a technical advisory group for each Water Resource Inventory Area (WRIA) of Washington State. Water Resource Inventory Areas are generally equivalent to the State's major watershed basins. The purpose of the technical advisory group is to develop a report identifying habitat limiting factors for salmonids. This report is based on a combination of existing watershed studies and knowledge of the technical advisory group participants. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon, including all species of the family Salmonidae." The bill further clarifies the definition by stating, "These factors are primarily fish passage barriers and degraded estuarine areas, riparian corridors, stream channels, and wetlands." It is important to note that the responsibilities given to the Washington State Conservation Commission do not constitute completing a full limiting factors analysis.

Salmon Recovery Funding Board. In 1999, the Washington State Legislature created and authorized the Salmon Recovery Funding Board (Board) to guide spending of funds targeted for salmon[4] recovery activities and projects. The Board's mission is "to support salmon recovery by funding habitat protection and restoration projects and related programs and activities that produce sustainable and measurable benefit for the fish and their habitat." The primary role of the Board is to fund the best salmonid habitat projects and activities reflecting local priorities using the best available science to protect, preserve, restore, and enhance salmonid habitat and watershed functions. Under current funding policies, the Board will give the greatest preference to strategies and project lists benefitting salmonid populations listed under the Endangered Species Act.

Washington Department of Fish and Wildlife. The Washington Department of Fish and Wildlife has developed a native char management plan that addresses both bull trout and Dolly Varden (WDFW 2000). The Washington Department of Fish and Wildlife no longer stocks brook trout in streams or lakes connected to bull trout waters. Fishing regulations prohibit harvest of bull trout on the Olympic Peninsula. The Washington Department of Fish and Wildlife is also currently involved in a mapping effort to update bull trout distribution data within Washington, including all known occurrences, spawning and rearing areas, and potential habitats. The salmon and steelhead inventory and assessment program is currently updating its database to include the entire State. The database consists of an inventory of stream reaches and associated habitat parameters important for the recovery of salmonid species, including bull trout. This database will provide critical baseline habitat and fish distribution information that can be used in a number of conservation efforts.

Harvest for bull trout has been significantly reduced across the species' range. Most recreational fisheries for bull trout in fresh and marine waters in the Coastal-Puget Sound Distinct Population Segment have been closed since 1994. As the Coastal-Puget Sound Distinct Population Segment begins to achieve its

[4] The term was used broadly to include all species of salmon, trout, char, whitefish, and grayling.

recovery goal, we will coordinate with the Washington Department of Fish and Wildlife and Tribes to determine the location and level of bull trout harvest that continues to support the population characteristics consistent with bull trout recovery.

The Washington Department of Fish and Wildlife's Hydraulic Project Approvals Program reviews and permits or denies projects that propose to use, obstruct, divert, or change streambeds or flows, or impact nearshore marine waters in Washington. Updates made within the program to help conserve bull trout and their habitat include revised rules and regulations for mineral prospecting and placer mining to reduce impacts to bull trout and bull trout habitat, revised approved work windows (periods of time for inwater work) that provide greater protection for bull trout life stages during spawning and incubation, and development of marine work windows that help protect important marine forage (prey) fish species for bull trout.

The Washington Department of Fish and Wildlife, in conjunction with the Northwest Indian Fisheries Commission, have been using Ecosystem Diagnosis and Treatment (EDT) modeling for deriving recovery goals for Puget Sound Chinook salmon in terms of productivity, capacity, and diversity based on properly functioning conditions for habitat. The model is used to analyze environmental information and draw conclusions about the ecosystem as it relates to the life history of Chinook salmon, in this case. This approach compares existing conditions with a future condition where conditions are as good as they can theoretically be within the watershed. From this comparison, a "diagnosis" of factors that are preventing achievement of this future condition can be made, and potential actions to achieve goals can be identified. It is anticipated that many of the limiting habitat factors for Chinook salmon identified through this model will be equally or partially applicable to bull trout.

Washington Department of Ecology. The Washington Department of Ecology is involved in a number of programs and actions intended to help provide greater conservation for bull trout and other salmonids by reducing habitat impacts. These include updating the State's Stormwater Management Manual for construction and development, updating State Shoreline Management regulations, updating the State's Water Quality Standards, and developing and implementing water cleanup plans, or TMDLs (total maximum daily loads) for impaired waterbodies.

Shoreline Management Act. The goal of the Shoreline Management Act (Revised Code of Washington [RCW] 90.58) is "to prevent the inherent harm in an uncoordinated and piecemeal development of the State's shorelines." This act establishes a balance of authority between local and State government. Cities and counties are the primary regulators but the State has authority to review local programs and permit decisions. The Shoreline Management Act gives preference to uses that:

- Protect the quality of water and the natural environment.
- Depend on proximity to the shoreline.
- Preserve and enhance public access or increase recreational opportunities for the public along shorelines.

The Shoreline Management Act also requires extra protection for management of "shorelines of statewide significance." These shorelines include the Pacific Coast, Hood Canal, Strait of Juan de Fuca, and large rivers (those with a flow rate of 1,000 cubic feet per second or greater for rivers in western Washington) (WDOE 1999).

The National Oceanic and Atmospheric Administration's Office of Ocean and Coastal Resource Management (OCRM) funds the Shoreline Management Act and is responsible for approving the guidelines and incorporating them into the federally approved Washington Coastal Zone Management Program. As part of the approval process, the Office of Ocean and Coastal Resource Management must comply with the Endangered Species Act, which requires consultation with us and National Oceanic and Atmospheric Administration (NOAA) Fisheries.

Growth Management Act. The goal of the Growth Management Act is to prevent uncoordinated and unplanned growth that poses a "threat to the environment, sustainable economic development, and the health, safety, and high quality of life enjoyed by residents of this State" (RCW 36.70A.010). Under the Growth Management Act, the State provides broad public access to data and maps describing development opportunities and constraints. The Growth

Management Act is widely used as a framework for other State statutes and policies related to land-use practices, environmental protection, and sustainable development (Washington State Department of Community, Trade, and Economic Development, no date). The Growth Management Act requires all cities and counties in the State to:

- Designate and protect wetlands, frequently flooded areas, and other critical areas.
- Designate farm lands, forest lands and other natural resource areas.
- Determine that new residential subdivisions have appropriate provisions for public services and facilities.

Washington Department of Natural Resources. The Washington Department of Natural Resources manages State trust lands for terrestrial, riparian, aquatic, and special habitats under their habitat conservation plan, approved by us in 1997. On the western and northwestern side of the Olympic Peninsula, the Washington Department of Natural Resources manages State trust lands as the Olympic Experimental State Forest. The Olympic Experimental State Forest extends from the Queets River watershed in the south to the Pysht River watershed in the northern part of the Olympic Peninsula. The Goodman, Hoh, Quillayute, Ozette, Hoko, and Clallam watersheds are all within the Olympic Experimental State Forest.

In other areas on the Olympic Peninsula, outside of the Olympic Experimental State Forest, the Washington Department of Natural Resources manages State trust lands as they do elsewhere within the habitat conservation plan area. Bull trout are one of several species covered under this plan. The riparian conservation strategy for these lands has two conservation objectives: (1) maintain or restore salmonid freshwater habitat on Washington Department of Natural Resources managed lands, and (2) contribute to the conservation of other aquatic and riparian obligate species.

These two objectives will be achieved by the following activities along fish-bearing waters: (1) no timber harvest shall occur with the first 7.6 meters (25 feet) from the outer margin of the 100-year floodplain; (2) the next 23 meters (75 feet) of the buffer shall be a minimum harvest area; and (3) the area beyond 30 meters (100 feet) to approximately a site potential tree height from the active channel margin shall be a low harvest area. Maintaining natural levels of stream temperature, sediment load, detrital nutrient load, and instream large woody debris is the primary function of the buffer zone. There will be some timber harvest within this buffer zone that may include ecosystem restoration and the selective removal of single trees.

The Olympic Experimental State Forest is managed differently than other State trust lands because of its experimental nature and its integrated approach to management. The long-term vision for the Olympic Experimental State Forest is a commercial forest in which ecological health is maintained through the integration of forest production activities and conservation. One of the primary differences between Olympic Experimental State Forest management and that of other State trust lands is that the Olympic Experimental State Forest is considered to be an “unzoned forest” in which no special zones are set aside exclusively for either species conservation or commodity extraction.

The riparian conservation strategy for the Olympic Experimental State Forest is also unique from other State trust lands due to a higher propensity throughout the area for mass wasting events and windstorms that can cause considerable tree blowdown. Experimentation, research, and monitoring are also a primary emphasis of the Olympic Experimental State Forest. The Washington Department of Natural Resources’ objectives for lands within the Olympic Experimental State Forest include:

- Maintaining and aiding restoration of the composition, structure, and function of aquatic, riparian, and associated wetland systems that support aquatic species, populations, and communities.
- Maintaining and aiding restoration of the physical integrity of stream channels and floodplains.
- Maintaining and aiding restoration of water to the quantity, quality, and timing of disturbances with which these stream systems evolved (natural disturbance regime of these systems).
- Maintaining and aiding restoration of the sediment regime to the condition in which these systems evolved.

- Developing, using, and distributing information about aquatic, riparian, and associated wetland ecosystem processes and on their maintenance and restoration in commercial forests.

The riparian conservation strategy for the Olympic Experimental State Forest intends to meet the stated objectives by:

- Applying interior core buffers the same as those provided on streams outside the Olympic Experimental State Forest.
- Applying additional exterior wind buffers.
- Developing comprehensive road maintenance plans.
- Protecting forested wetlands and conducting a research and monitoring program integrated with on-the-ground riparian protection.

Timber harvest can occur within the interior and exterior buffers, provided that management activities are consistent with the conservation objectives and are appropriate for local landforms and meteorological conditions. The comprehensive road maintenance plans will emphasize minimizing road densities, maintaining existing roads, and other efforts to protect and restore aquatic organisms. Forested wetland management emphasizes retaining plant canopies and communities for maintenance of hydrological processes, minimizing disturbance to water flow patterns, and ensuring stand regeneration. The riparian conservation strategy is integrated with the research and monitoring strategy for the Olympic Experimental State Forest. All experiments performed in riparian areas will be carried out according to research protocols established for the Olympic Experimental State Forest.

Washington State Forest Practice Rules. In July 2001, the Washington Forest Practices Board adopted new permanent forest practice rules implementing the Forest and Fish Report (FFR 1999; Washington Forest Practices Board 2001). These rules address riparian areas, roads, steep slopes, and other elements affecting forest practices on non-Federal lands.

The Forest and Fish Report was the result of a document development process that relied on broad stakeholder involvement, including the U.S. Fish and

Wildlife Service, the National Marine Fisheries Service (now NOAA Fisheries), and the U.S. Environmental Protection Agency, as well as State agencies, Counties, Tribes, forest industry, and environmental groups. Prior to completion of the Forest and Fish Report, the environmental groups withdrew their support and participation in the process. The forest practices rules established new prescriptions to better conserve aquatic and riparian habitat for bull trout and other salmonids, and many provisions of the rules represent improvements over previous regulations. Because there is biological uncertainty associated with some of the prescriptions, the Forest and Fish Report relies on an adaptive management program for assurance that the new rules will meet the conservation needs of bull trout. Research and monitoring being conducted to address areas of uncertainty for bull trout include protocols for detection of bull trout, habitat suitability, forest management effects on groundwater, field methods or models to identify areas influenced by groundwater, and forest practices influencing coldwater temperatures.

Washington State Conservation Reserve Enhancement Program (CREP). The national Conservation Reserve Enhancement Program, implemented by the Natural Resources Conservation Service, dedicates $250 million annually for restoration activities on agricultural lands in Washington State. Farmers and landowners receive reimbursements in the form of soil rental rates for taking land out of production to plant riparian buffers, fence livestock out of streams, and restore stream habitat.   The Conservation Reserve Enhancement Program contracts are 10 to 15-year terms and restored riparian areas are often incorporated into conservation easements to provide permanent protection.

Federal Agencies

U.S. Fish and Wildlife Service. Aside from the Endangered Species Act regulations and guidelines that apply to Federal actions (see Appendix 5), there have been several significant Federal efforts with specific implications for bull trout in the Olympic Peninsula Management Unit. We also have a number of national programs (*e.g.*, Private Stewardship Program, Cooperative Endangered Species Conservation Fund) that provide funds to projects restoring and conserving bull trout habitats.

We have negotiated two habitat conservation plans within the area of the Olympic Peninsula Management Unit. The Washington Department of Natural Resources Habitat Conservation Plan is described previously, and the Simpson Timber Company Habitat Conservation Plan is described as follows: In 2000, the U.S. Fish and Wildlife Service, the Environmental Protection Agency, and National Marine Fisheries Service assisted the Simpson Timber Company in completing a habitat conservation plan (plan). The plan addresses forest management and timber harvest across a 105,626-hectare (261,000-acre) landscape in three counties west of Shelton, Washington, on the Olympic Peninsula. The principal area of the plan overlaps bull trout distribution in the South Fork Skokomish River and the anadromous reaches of its major tributaries. The Plan's conservation measures emphasize protection and restoration of riparian forests through management prescriptions designed to address wetlands, unstable slopes, road construction, road maintenance and decommissioning, and certain harvest limitations to moderate snowmelt runoff. Riparian buffers prescribed on all stream types vary from 5 to 65 meters (16 to 312 feet) in width. Prescribed widths depend on channel class and geologic class designation, which take into account recruitment of woody debris into the channel. An active road management program controls or eliminates entry of sediments to watercourses within the plan area. The plan contains a research and monitoring component and a scientific committee of stakeholders. The scientific advisory team includes technical representatives from the Washington Department of Ecology; Washington Department of Fish and Wildlife; Washington Department of Natural Resources; the Quinault Indian Nation, Squaxin Island, Skokomish, and Chehalis Tribes, and the Point No Point Treaty Council; and the three Federal agencies. The group meets quarterly to review monitoring results and recommend management changes (Simpson Timber Company 2000).

Our Western Washington Fish and Wildlife Office also has a number of restoration programs (*e.g.,* Jobs in the Woods, Chehalis Fisheries Restoration Program, Puget Sound Coastal Program, and Partners for Fish and Wildlife) that provide funding and technical assistance for habitat restoration work in the Olympic Peninsula region. Many of the projects funded through these programs contribute to the recovery of bull trout through habitat enhancements or through the restoration of watershed processes and functions eliminated or impaired by land management activities. These programs also contribute to the restoration of estuarine and nearshore habitats important to the recovery of bull trout and salmon.

Part of our contribution to the implementation of the Northwest Forest Plan (USDA and USDI 1994a,b) includes the Jobs in the Woods Watershed Restoration Program, started in 1994. Using guidance from the Northwest Forest Plan Aquatic Conservation Strategy, and the goal of maximizing ecological and economic benefits, the program developed a "focus watershed" approach in 1998. The program selects a limited number of focus watersheds. This approach allows the program to effectively use limited funding to focus restoration activities in key watersheds identified in the Northwest Forest Plan as containing habitat for potentially threatened species of anadromous salmonids or other potentially threatened fish.

We selected the Dungeness watershed as a focus watershed for the program in 2002, working with local partners in the Dungeness watershed to identify and provide future support to a variety of watershed restoration projects. The types of activities currently under discussion include an assessment and historical characterization of the landscape of the lower Dungeness River and estuary to help establish appropriate restoration goals and reestablish native species on approximately 36 hectares (90 acres) of estuarine, riparian and riparian-adjacent properties in that area. Future restoration activities could include reducing sedimentation from forest roads, enhancing instream habitat and fish passage, reestablishing riparian vegetation, or improving hydrologic regimes by breaching or removing dikes.

The Chehalis Fisheries Restoration Program developed partnerships with private landowners; fisheries groups; nonprofit organizations; and local, Tribal, and State agencies to implement 141 habitat restoration, watershed assessment, and public education projects. Projects have recently been completed in the Chehalis, Humptulips, Wynoochee, and Satsop River basins. Typical projects include removal of artificial barriers to fish migration, instream habitat enhancement, riparian fencing and native plant revegetation, road decommissioning and sediment control, habitat assessments, and outreach and education projects. In addition, funds are passed on each year to the Chehalis Tribe and Quinault Indian Nation for habitat restoration.

The Fisheries Restoration and Irrigation Mitigation Program provides funds for fish screening and for providing fish passage at water diversions. Industrial, municipal, and agricultural diversions are eligible for restoration and mitigation funding.

Our Western Washington Fish and Wildlife Office participates in the Federal Energy Regulatory Commission’s hydroelectric project proceedings for both new projects and for projects requiring a new operating license. During the license proceedings, we provide the Federal Energy Regulatory Commission with recommended measures to protect and enhance fish and wildlife, including their habitat, that may include mandatory fish passage prescriptions. The recommended measures are transmitted through the Department of the Interior’s response on the license application. During project relicensing, we have an opportunity to improve habitat that has been degraded by project operation by persuading the Federal Energy Regulatory Commission to include mitigative measures (*e.g.*, improved flows, sediment and large woody debris transport, etc.) as license conditions. A hydroelectric project operating license typically covers a period from 25 to 40 years.

U.S. Forest Service and the Northwest Forest Plan. Currently, the Northwest Forest Plan (USDA and USDI 1994a,b) guides timber management on U.S. Forest Service lands within the Olympic Peninsula Management Unit. Benefits to aquatic and riparian habitat from the Northwest Forest Plan are evident throughout the Olympic Peninsula.

The Olympic National Forest initiated a process to identify forest roads that no longer serve a transportation need. The Olympic National Forest Road Management Strategy analysis identifies roads in need of maintenance and access, in part, by the adverse risk they may pose to the aquatic environment. For example, since 1994 the U.S. Forest Service and Simpson Timber Company have decommissioned over 386 kilometers (240 miles) of logging roads and restored 1,370 hectares (3,385 acres) within the South Fork Skokomish watershed.

On the Olympic National Forest, the South Fork Skokomish Watershed Analysis (USDA 1995a) identified this watershed as a priority for restoration. Since the 1995 watershed analysis, the Hood Canal Ranger District helped restore and maintain the ecological health of the watershed and aquatic system. Some of these restoration actions include:

- 257 kilometers (160 miles) of road were decommissioned, and approximately 2,454 hectares (1,000 acres) of existing erosion features were stabilized using various soil bioengineering techniques.

- 133 kilometers (83 miles) of road and approximately 244,656 cubic meters (320,000 cubic yards) of soil, rock, and logging debris were removed from unstable landing and side-cast areas. After removing these materials, slopes were rounded back to their original contour and stabilized.

- 1,601 hectares (650 acres), comprising approximately 1,115 sites, were stabilized with various soil bioengineering techniques.

- During this time, over 750,370 native trees and shrubs were planted to provide long-term stability in excavated areas, and 300 hectares (750 acres) were hydromulched through helicopter and truck applications.

The U.S. Forest Service also conducts ongoing aquatic habitat monitoring and fish survey efforts, including radio telemetry projects on the Skokomish and Dungeness Rivers. These projects have helped to identify bull trout spawning sites and migrations.

Olympic National Park. Olympic National Park contains portions of every core area in the Olympic Peninsula Management Unit within its boundaries. This largely undisturbed habitat provides important high quality spawning and rearing habitat for bull trout and other salmonids and protects some of the last undisturbed bull trout habitat in Washington. The park currently undertakes conservation, research, and restoration that will assist bull trout recovery on the Olympic Peninsula that includes:

- Restoring fish passage to pristine habitat through the planned removal of two hydroelectric dams on the Elwha River in 2007.

- Replacing culverts that currently block fish passage.

- Conducting extensive research designed to determine migratory patterns of bull trout and reduce incidental take[†] of fish migrating to Park waters.

- Monitoring bull trout populations to assist development of appropriate management and conservation strategies.

- Conducting inventories of fish populations throughout unsurveyed watersheds in Olympic National Park.

U.S. Environmental Protection Agency. Growing public awareness and concern for controlling water pollution led to enactment of the Federal Water Pollution Control Act Amendments of 1972. As amended in 1977, this law became commonly known as the Clean Water Act. The Clean Water Act established the basic structure for regulating discharges of pollutants into the waters of the United States. This Act gave the U.S. Environmental Protection Agency the authority to implement pollution control programs such as setting wastewater standards for industry. The Clean Water Act also established requirements to set water quality standards for all contaminants in surface waters. This act made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was first obtained under its provisions. As a requirement of section 303(d) of the Clean Water Act, a list of impaired waters must be prepared by each state, and approved by the U.S. Environmental Protection Agency for all waterbodies that do not fully support their beneficial uses (see, *e.g.*, Appendix 2). The Clean Water Act also funded the construction of sewage treatment plants under the construction grants program and recognized the need for planning to address the critical problems posed by nonpoint source pollution.

Under the Clean Water Act, the Environmental Protection Agency has approval authority over all State water quality standards. Because many Pacific

Northwest salmonid species are listed as threatened or endangered under the Endangered Species Act, the Environmental Protection Agency must consult with us and NOAA Fisheries to insure that State or Tribal water quality standards are not likely to jeopardize the continued existence of these listed fish. The Environmental Protection Agency has developed guidance to assist States and Tribes adopt temperature water quality standards that the Environmental Protection Agency can approve consistent with its obligations under the Clean Water Act and Endangered Species Act (USEPA 2003).

Natural Resources Conservation Service. The Natural Resources Conservation Service works to assist private landowners with conserving their soil, water, and other natural resources. Local, State, and Federal agencies and policymakers also rely on the expertise of the Natural Resources Conservation Service for technical assistance with best management practices. Most work is done with local partners. The Wildlife Habitats Incentives Program, Environmental Quality Incentives Program and other grants assist private landowner riparian habitat protection and management actions. The Environmental Quality Incentives Program is a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. The Wildlife Habitats Incentives Program is also a voluntary program aimed at working with people who want to develop and improve wildlife habitat (including aquatic areas) on private land.

The Natural Resources Conservation Service works in partnership with local conservation districts in the Olympic Peninsula. For example, the Clallam County Conservation District has provided funding and technical assistance for implementation of best management practices and numerous salmon restoration projects.

NOAA Fisheries. In March 1999, NOAA Fisheries listed the Puget Sound Chinook salmon and Hood Canal summer-run chum salmon Evolutionarily Significant Units as threatened under the Endangered Species Act (64 FR 14308). These two Evolutionarily Significant Units overlap the Coastal-Puget Sound Distinct Population Segment of bull trout.

As part of the recovery planning process for Chinook salmon, NOAA Fisheries has issued guidance for the technical development of recovery plans (NMFS, *in litt*. 2000). The framework for salmon and steelhead recovery plan development is divided into distinct geographic areas, or domains, which may contain multiple evolutionarily significant units. Recovery plans for listed salmon and steelhead will contain the same basic elements as mandated by the Endangered Species Act: (1) objective, measurable criteria; (2) a description of site-specific management actions necessary to achieve recovery; and (3) estimates of the cost and time to carry out recovery actions.

In the Olympic Peninsula region, NOAA Fisheries is developing the Hood Canal summer-run chum and Puget Sound Chinook salmon recovery plan through a collaborative regional approach, the "Shared Strategy for Puget Sound" (Shared Strategy 2002). It is anticipated that many of the habitat recovery actions developed for summer-run chum salmon and Chinook salmon will provide conservation benefits to bull trout and in some cases possibly meet their conservation needs (*e.g.*, Chinook salmon recovery actions in mainstem river reaches). However, bull trout will require greater habitat protection and restoration measures in some locations due to their coldwater requirements, greater sensitivity to habitat degradation, and use of habitats outside of areas occupied by Chinook salmon. As a participant in the Shared Strategy effort, we will coordinate the implementation of the recovery actions identified in the Olympic Peninsula Management Unit recovery plan with salmon measures to avoid duplication of effort and to maximize the use of available resources, as well as identify actions necessary for bull trout that are above and beyond what may be necessary for Chinook salmon recovery.

NOAA Olympic Coast National Marine Sanctuary. The Olympic Coast National Marine Sanctuary comprises over 2,500 square nautical miles (3,300 square miles) of ocean waters off Washington's rugged and rocky Olympic Peninsula coastline. Sanctuary waters extend an average of 30 nautical miles (35 miles) offshore and span 117 nautical miles (135 miles) north to south, stretching from the United Sates/Canada international boundary to the Copalis River in Grays Harbor County, Washington. The sanctuary provides habitat for one of the most diverse marine mammal faunas in North America and is a critical link in the Pacific flyway. NOAA Fisheries manages the site, designated as a National

Marine Sanctuary in 1994, to protect its natural resources while encouraging compatible commercial and recreational uses. Major resource management issues include vessel traffic, spill prevention and response, water quality, and the ecological impact of fishing. Information about the extent of bull trout anadromy along the coast of the Olympic Peninsula is limited; however, Dolly Varden, a related char species, makes extensive migrations in marine waters. It is likely that the protections provided by the marine sanctuary will benefit anadromous bull trout.

Elwha River Ecosystem and Fisheries Restoration Act of 1992. The Elwha River Ecosystem and Fisheries Restoration Act of 1992 (Public Law 102-495) authorizes the Secretary of the Interior to acquire and remove the Elwha and Glines Canyon Hydroelectric Projects to fully restore the Elwha River ecosystem and native anadromous fisheries. The proposed action consists of the Department of the Interior's acquisition of the Elwha and Glines Canyon Hydroelectric Projects, the removal of both dams and related facilities, the operation of the hydroelectric facilities during the interim period prior to their removal, the restoration of anadromous fish runs, and the implementation of flood control and water supply mitigation measures.

The Olympic National Park, U.S. Fish and Wildlife Service, Washington Department of Fish and Wildlife, and Lower Elwha S'Klallam Tribe will collectively develop the anadromous fish restoration plan. The draft restoration plan relies on a combination of natural recolonization, transplantation of juvenile salmon in the upper basin, and importation of donor stocks if the native stock has been extirpated. No transplanting of bull trout is proposed.

<u>Native American Tribal Activities</u>

The Tribes within the Olympic Peninsula play an active role in conserving and restoring salmonids and their habitats. Their efforts include research, outmigration sampling, adult and juvenile surveys, habitat restoration, and biological and physical monitoring of salmonid watersheds. Most Tribal governments on the Olympic Peninsula have active natural resource or fisheries departments with technical staff working on collaborative projects with Federal, State, and local entities. A number of Olympic Peninsula Tribes participate in ongoing collaborative regional recovery efforts, such as the Shared Strategy for Puget Sound (discussed below), and also in more localized watershed efforts, such as the Habitat Limiting Factors Analyses under State of Washington House Bill 2496.

Shared Strategy for Puget Sound

In October 1999, over 150 leaders on salmon issues from throughout the Puget Sound area gathered in Port Ludlow, Washington, to discuss the region's growing salmon crisis. At this meeting a group representing Tribes, Federal, State and local governments agreed to develop a Shared Strategy to facilitate a coordinated regional approach to salmonid recovery. The Strategy includes developing a collaborative recovery plan for the region that is guided by clear goals and meets the broad interests for salmon and bull trout in Puget Sound (including Hood Canal and the Strait of Juan de Fuca). The Strategy also includes establishing an organizational structure to link recovery efforts, completing a regional recovery plan and guiding its implementation, and identifying and supporting important ongoing near-term efforts to protect Puget Sound salmon and bull trout (Shared Strategy 2002). The Shared Strategy is an effort to engage local citizens, Tribes, technical experts, and policymakers to build a practical, cost-effective recovery plan endorsed by the people living and working in the watersheds of the Puget Sound region.

As an ongoing participant and partner in the Shared Strategy, we believe this effort can contribute to the successful implementation of many of the recovery actions identified in the Puget Sound Management Unit and Olympic Peninsula Management Unit recovery plans for bull trout. The watershed-based planning efforts under the Shared Strategy can help further develop and refine certain site-specific recovery actions identified for core areas in the Olympic Peninsula Management Unit.

Hood Canal Coordinating Council

The Hood Canal Coordinating Council consists of a council of governments including representatives from Jefferson, Kitsap, and Mason Counties; Port Gamble S'Klallam and Skokomish Tribes; and State and Federal

Agencies. The Council was established in 1985 to improve regulatory decision making and policy review by providing a forum for discussion of regional water quality related issues affecting Hood Canal.

The Council adopted the following mission statements: “The Hood Canal Coordinating Council recognizes Hood Canal as a national treasure and will advocate for and implement locally appropriate actions to protect and enhance the Canal's special qualities” (adopted in 1992). “To assure the existence of wild salmon in Hood Canal for the next 150 years, the Hood Canal Coordinating Council will: understand the causes of the decline of salmon in the Canal; identify the values and choices to be made in the natural, economic, legal, social, and cultural environments of salmon; develop and choose appropriate responses; and implement actions to maintain natural populations of salmon stocks at self-sustaining levels for ceremonial, subsistence, recreational and commercial fisheries” (adopted in 1996).

In September 1998, the Washington Department of Fish and Wildlife awarded the Hood Canal Coordinating Council a Salmon Recovery Lead Entity Grant to solicit salmon recovery projects from counties, cities, conservation districts, Tribes, environmental groups, business interests, landowners, citizens, volunteer groups, regional fish enhancement groups, and other habitat interests. The grant also facilitates the ranking of those projects into an overall prioritized list to be submitted to the State Salmon Recovery Funding Board for funding.

The Hood Canal Coordinating Council also developed a recovery strategy to guide selection and ranking of projects in Hood Canal and the eastern strait. It prioritizes geographic areas in the canal and eastern strait, the types of activities, and includes sequenced project lists for each of the 69 identified independent anadromous drainages in the area.

Dungeness River Agricultural Water Users Association

The Dungeness River Agricultural Water Users Association has worked cooperatively to improve management of their irrigation facilities and activities. Many projects were identified in the Comprehensive Irrigation Water Conservation Plan and by working with the Jamestown S’Klallam Tribe, the

Clallam County Conservation District, and others, irrigation consumption has been reduced by approximately one third in the last 5 years, conserving water for bull trout and salmon (Jamestown S'Klallam Tribe 2003).

STRATEGY FOR RECOVERY

Bull trout have specific ecological requirements and depend upon an interconnected network of complex habitats to support multiple life history forms and facilitate the potential for occasional dispersal between local populations to maintain gene flow and genetic variability. In order to effectively address the needs of this wide-ranging species and the varying threats it faces, as well as incorporate the needs and concerns of the various local interest groups involved in its recovery, we have subdivided the Coastal-Puget Sound Distinct Population Segment into two management units, the Puget Sound and the Olympic Peninsula. Within each management unit, recovery will be based on the concept of functional "core areas." A core area represents the combination of both a core population (*i.e.*, one or more local populations of bull trout inhabiting a core habitat) and core habitat (*i.e.*, habitat that could supply all the necessary elements for the long-term security of bull trout, including for both spawning and rearing, as well as for foraging, migrating, and overwintering) and constitutes the basic unit upon which to gauge recovery.

Bull trout are widely distributed in the Olympic Peninsula Management Unit. The Olympic Peninsula recovery team identified 6 core areas, with a total of 10 local populations and 2 potential local populations distributed among them (Table 1). The number of local populations includes those stream complexes for which the presence of bull trout spawning and rearing is either known or has been determined through professional judgement as highly likely. As more bull trout distribution and abundance information is collected, the number of local populations identified will likely increase.

A "potential" local population may be defined as either a local population that likely exists but has not been adequately documented, or as a local population that does not currently exist but is likely to develop in the foreseeable future. The development of a local population is likely to occur if spawning and rearing habitat or connectivity is restored in that area or if bull trout recolonize or are reintroduced in the area. In the Olympic Peninsula, the recovery team identified two areas that are not currently known to support a local population (due to habitat degradation or access barriers) but that have the potential to provide spawning and rearing habitat for bull trout. Each of these areas could support a local population in the future, following restoration of habitat and access, as the bull trout recover. These areas were identified as potential local populations. Potential local populations identified in this recovery plan are considered necessary for recovery.

Ensuring the long-term persistence of all extant local populations, especially those exhibiting the anadromous life history, is key to supporting self-sustaining core areas of bull trout within the Coastal-Puget Sound Distinct Population Segment. In the coterminous United States, anadromous bull trout are found only within this population segment. In addition to their unique life history, anadromous forms are important because they provide an opportunity for core populations to exchange genetic material and, hence, increase the diversity and stability of the overall distinct population segment. Presumably this diversity reduces the risk of extinction of the distinct population segment. Large anadromous bull trout also have higher fecundity than the resident and fluvial forms and use a greater diversity of spawning and foraging habitats, which further contributes to population diversity and lowers the risk of extinction. All migratory life history forms require intact spawning and rearing habitat connected to adequate foraging, migration, and overwintering habitat. For anadromous bull trout, these required habitats span the whole watershed, from headwater tributaries to the estuary and adjacent marine nearshore habitat, as well as freshwater systems outside their natal watershed.

Recovery Goals and Objectives

The goal of the bull trout recovery plan is to **ensure the ongoing long-term persistence of self-sustaining, complex, interacting groups of bull trout distributed across the species' native range so that the species can be delisted**. To achieve this goal, recovery objectives addressing distribution, abundance, habitat, and genetics were identified.

The recovery objectives for the Olympic Peninsula Management Unit are as follows:

- Maintain the current distribution of bull trout, particularly anadromous forms, and restore migratory life history forms in some of the previously occupied areas within the Olympic Peninsula Management Unit.

- Maintain stable or increasing trends in abundance of bull trout in the Olympic Peninsula Management Unit.

- Restore and maintain suitable habitat conditions for all bull trout life history stages and strategies, with an emphasis on anadromy.

- Conserve genetic diversity and provide opportunity for genetic exchange to conserve migratory life history forms.

Rieman and McIntyre (1993) and Rieman and Allendorf (2001) evaluated the bull trout population numbers and habitat thresholds necessary for long-term viability of the species. They identified four key elements, and the characteristics of each of those elements, for consideration when evaluating the viability of bull trout populations. These four elements include: (1) the number of local populations; (2) adult abundance (defined as the number of spawning fish present in a core area in a given year); (3) productivity, or the reproductive rate of the population (as measured by population trend and variability); and, (4) connectivity (as represented by the presence of the migratory life history form and functional habitat). For each element, the Olympic Peninsula Recovery Team classified bull trout populations into relative risk categories based on the best available data and the professional judgement of the team.

The Olympic Peninsula Recovery Team also evaluated each of the above described elements under a potential recovered condition to produce recovery criteria. The evaluation of these elements under a recovered condition assumed the implementation of actions identified within this plan. The recovery targets for the Olympic Peninsula Management Unit reflect: (1) the stated objectives for the management unit; (2) the evaluation of each population element under both current and recovered conditions; and (3) consideration of current and recovered habitat characteristics within the management unit. These recovery targets are subject to refinement in the future as more detailed information on bull trout population dynamics becomes available. Given the limited information currently available for bull trout in the Olympic Peninsula Management Unit, both the level of adult abundance and the number of local populations needed to lessen the risk of extinction should be viewed as best estimates at this time.

This approach to developing recovery criteria acknowledges that the status of populations in some core areas may remain short of ideals described by conservation biology theory. Certain natural attributes or small patch size may limit some core areas, and these may always remain at a relatively high risk of extinction. Because of the limited data availability within the Olympic Peninsula Management Unit, the recovery team relied heavily on the professional judgement of its members.

Local Populations. Metapopulation theory is important to consider in bull trout recovery. A metapopulation is an interacting network of local populations with varying frequencies of migration and gene flow among them (Meffe and Carroll 1994). The distribution and interconnection of multiple local populations throughout a watershed provide a mechanism for spreading risk from random, naturally occurring events and allows for potential recolonization in the event of local extirpations. In part, the distribution of local populations in such a manner is an indicator of a functioning core area. Based in part on guidance from Rieman and McIntyre (1993), bull trout core areas with fewer than 5 local populations are at increased risk of local extirpation, core areas with between 5 and 10 local populations are at intermediate risk, and core areas with more than 10 interconnected local populations are at diminished risk.

Based on existing information and local expertise, the recovery team has identified two local populations in each of the Skokomish, Dungeness, Hoh, and Quinault core areas, and one local population was identified in each of the Queets and Elwha core areas. Based on the above guidance, bull trout in these core areas presently exist at an increased risk of adverse effects from random naturally occurring events; reducing this risk requires additional local populations. The present number of identified local populations is based on current information.

However, remote access, turbidity from glacial melt, and overlap of spawning time and location with other fall spawners make many of the likely bull trout spawning rivers and streams within the Olympic National Park extremely difficult to survey. The recovery team believes that increased survey efforts targeting bull trout will identify additional local populations within the management unit, and that this increased survey effort is a high priority recovery action.

Adult Abundance. The recovered abundance levels in the Olympic Peninsula Management Unit were determined by considering theoretical estimates of effective population size[†], historical census information, and the professional judgement of recovery team members. In general terms, the effective population size is the functional size of the population, from a genetic standpoint, based on the numbers of individuals that successfully breed and the distribution of offsprings among individuals. The effective population size may be substantially smaller than the census population size. Effective population size is an important theoretical construct in conservation biology, since genetic variability may be lost from a population with high numbers of individuals if the effective population size is low (Kimura and Crow 1963; Franklin 1980). The concept of effective population size allows us to predict potential future losses of genetic variation within a population due to small population sizes and genetic drift (see Appendix 4).

For the purposes of recovery planning, we used the number of adult bull trout that successfully spawn annually as a measure of effective population size. Based on standardized theoretical equations (Crow and Kimura 1970), guidelines have been established for maintaining minimum effective population sizes for conservation purposes. Effective population sizes of greater than 50 adults are necessary to prevent inbreeding depression and a potential decrease in viability or reproductive fitness of a population (Franklin 1980). To minimize the loss of genetic variation due to genetic drift and to maintain constant genetic variance within a population, an effective population size of at least 500 is recommended (Franklin 1980; Soulé 1980; Lande 1988). Effective population sizes required to maintain long-term genetic variation that can serve as a reservoir for future adaptations in response to natural selection and changing environmental conditions are discussed in Appendix 4.

For bull trout, Rieman and Allendorf (2001) estimated the need for a minimum number of 50 to 100 spawners per year to minimize potential inbreeding effects within local populations. In addition, bull trout need a minimum population size of between 500 and 1,000 adults in a core area to minimize the deleterious effects of genetic drift.

For the purposes of bull trout recovery planning, abundance levels were conservatively evaluated at the local population and core area levels. Local populations containing fewer than 100 spawning adults per year were classified as at risk from inbreeding depression. Bull trout core areas containing fewer than 1,000 spawning adults per year were classified as at risk from genetic drift.

Detailed abundance estimates for most core areas in the Olympic Peninsula Management Unit are currently not available due to limited and nonrepresentative data. Similarly, detailed abundance estimates are not available at the local population scale for any core area except the Skokomish core area. However, the recovery team has provided recovered abundance targets for each core area, based on available data sets, habitat considerations, the population guidance discussed above, and best professional judgement.

The recovery team estimated current abundance for the Skokomish core area at likely fewer than 500 adult fish present (Olympic Peninsula Recovery Team, *in litt*. 2001). Current estimated abundance is 60 adults in the South Fork Skokomish River (WSCC 2003) and approximately 100 adults in the North Fork Skokomish River (Brenkman *in litt.* 2003a). Based on the above guidance, the South Fork Skokomish River local population is at risk from inbreeding and the Skokomish core area is at an increased risk of genetic drift.

Based on the recovery team’s professional judgement and expertise, and considering available habitat, there are likely to be at least 500 but fewer than 1,000 adult bull trout in each of the remaining core areas: Hoh, Dungeness, Elwha, Queets, and Quinault (Olympic Peninsula Recovery Team, *in litt.* 2003a). Although there are a few records of numbers of individuals or redds for isolated sections of the Queets, Dungeness, and Hoh Rivers, bull trout distribution tends to be patchy, and sufficient information is not available for a more precise estimate of abundance in any core area other than the Skokomish core area. The recovery team identified expanded studies on bull trout abundance and spawning-site locations as a high priority research and implementation action necessary for recovery. Following the above guidance based on Rieman and Allendorf (2001), these core areas face risk from genetic drift. However, the recovery team believes that a more accurate evaluation of risk from genetic drift in the core areas will be possible with additional abundance information.

Abundance target levels. To develop a recovered abundance target for each core area, two factors were considered. The first factor was the minimum number of adult spawners in a core area needed to avoid the deleterious effects from genetic drift. The team selected the high value of 1,000 spawning adults from the suggested range of 500 to 1,000 spawning adults. In addition, the amount of available suitable habitat was also considered. The recovered abundance level for the Hoh, Queets, Quinault, Dungeness, and Elwha core areas was determined to be at least 1,000 adult spawners in each core area. Due to limited available habitat in the Skokomish core area, a recovered abundance level of 700 adult spawners was determined to be adequate for recovery. The recovery team emphasized that a more precise estimate of recovered abundance will be possible following availability of additional current abundance information.

The second factor considered in developing recovered abundance targets was the size of local populations needed to address inbreeding concerns. Based on the guidance presented above, the Olympic Peninsula Recovery Team chose to base local population abundance on the higher value of the 50 to 100 spawners needed to avoid inbreeding depression. The team acknowledges that this minimum abundance for local populations may need to be revised in order to buffer against random naturally occurring catastrophic events. Available information indicates that many, if not most, local populations can achieve this abundance, provided adequate habitat conditions are maintained or restored. The team acknowledged that some local populations may not be able to achieve this ideal minimum abundance, while others will likely reach much higher abundances due to natural differences in habitat capacity among the local populations. However, based on the population guidance and information from Rieman and Allendorf (2001), the team believed 100 spawners should be the current basis for setting recovered abundance targets for each local population in the Olympic Peninsula Management Unit.

Recovered abundance in the Skokomish core area will be limited by available habitat and is estimated to be 700 adult spawners when the core area reaches its recovered potential. This increased abundance in the Skokomish core area from fewer than 200 to 700 spawning adults will reduce somewhat the risk of genetic drift due to small population size, although this core area may always be at moderate risk of extirpation. Recent work with population characteristics and empirical models indicates that small populations (*e.g.*, fewer than 100 spawning adults) may be prone to extinction if they are isolated (Rieman and McIntyre 1993; Dunham and Rieman 1999), and restoring connectivity between the two known local populations is key to reducing the risk of extinction in this core area.

Productivity. A stable or increasing population is a key criterion for recovery. Measures of the trend of a population (the tendency to increase, decrease, or remain stable) include population growth rate or productivity. Estimates of population growth rate (*i.e.,* productivity over the entire life cycle) that indicate a population is consistently failing to replace itself ($\lambda < 1.0$) also indicate an increased risk of extinction. Therefore, the reproductive rate should indicate that the population is replacing itself or growing ($\lambda \geq 1.0$) to be considered recovered.

Since estimates of the total population size are rarely available, the productivity or population growth rate is usually estimated from temporal trends in indices of abundance at a particular life stage. For example, redd counts are often used as an index of a spawning adult population. The direction and magnitude of a trend in the index can be used as a surrogate for the growth rate of the entire population. For instance, a downward trend in an abundance indicator may signal the need for increased protection, regardless of the actual size of the population. A population that is below recovered abundance levels, but that is moving toward recovery, would be expected to exhibit an increasing trend in the indicator.

The population growth rate is an indicator of probability of extinction. This probability cannot be measured directly, but it can be estimated as the consequence of the population growth rate and the variability in that rate. For a population to be considered viable, its natural productivity should be sufficient for the population to replace itself from generation to generation. Evaluations of population status will also have to take into account uncertainty in estimates of population growth rate or productivity. For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time. Only the North Fork Skokomish River local population has received long-term monitoring. Recent counts in this population demonstrate a declining trend from a peak of 412 adults in 1993 to 100 adults in 2002 (WDFW 1998; S. Brenkman, pers. comm. 2003c). Based on this information for the North Fork Skokomish River and the lack of adequate trend data in the South Fork Skokomish River, as well as in the Dungeness, Hoh, Queets, Quinault, and Elwha core areas, bull trout in all core areas in the Olympic Peninsula Management Unit are considered at increased risk until sufficient information is collected to properly assess their productivity. As data are collected and population size more clearly documented, these numbers should be refined for application to recovery targets for this management unit.

Connectivity. The presence of the migratory life history form within the Olympic Peninsula Management Unit was used as an indicator of the functional connectivity of the unit. If the migratory life form was absent, or if the migratory form was present but local populations lacked connectivity, the core area was considered to be at increased risk. If the migratory life form persists in at least some local populations, with partial ability to connect with other local populations, the core area was judged to be at intermediate risk. Finally, if the migratory life form was present in all or nearly all local populations, and had the ability to connect with other local populations, the core area was considered to be at diminished risk.

Migratory bull trout likely persist in most local populations in the Dungeness, Hoh, Queets, and Quinault core areas; these areas are therefore considered at a diminished risk. Migratory bull trout may persist in some local populations in the Skokomish and Elwha core areas. Dams, however, block connectivity between local populations within these core areas, and the core areas are considered at an intermediate risk. The low abundance of the migratory life history strategy limits the possibility for genetic exchange and local population reestablishment. In the Elwha core area both the Elwha and Glines Canyon Dams are scheduled for removal beginning in 2007. Removal of the dams will restore connectivity and likely result in restoration of the anadromous life history form as well as increased abundance of bull trout. In the Skokomish core area implementation of the Federal Energy Commission license for the Cushman project is expected to result in the construction of trap and haul[†] fish passage facilities, which will restore connectivity between the lower and upper North Fork Skokomish River but will bypass and isolate Lake Kokanee and the section of river between it and Cushman Dam 1. Completion of these actions for the Elwha and Skokomish core areas will reduce the risk to these core areas from isolation and fragmentation.

Recovery Targets for the Olympic Peninsula Management Unit

As noted in Part I of this plan, recovery and delisting can only occur at the level of the listed entity. Consideration of delisting will depend upon attainment of the recovery criteria for bull trout across their range within the coterminous United States, as currently listed, or at the level of the distinct population segment as a whole should that population segment be reconfirmed to meet the definition of a distinct population segment under a formal regulatory rulemaking process. For the purposes of recovery planning, we have defined recovery criteria for the delisting of the Coastal-Puget Sound Distinct Population Segment as currently delineated. Although this population segment has been divided into two management units, these units are not eligible to be considered separately for delisting (a management unit cannot be a listed entity). We have therefore set recovery targets for each of the management units within the Coastal-Puget Sound Distinct Population Segment. These recovery targets reflect the recovery criteria measurement parameters identified for the entire distinct population segment, and reflect our best estimation as to how the recovery criteria can be met, working on recovery at the level of the management unit. We recognize that different configurations may be feasible and we welcome suggestions on alternative targets which can achieve recovery at the level of the distinct population segment.

This recovery plan presents recovery targets for the Olympic Peninsula Management Unit only; recovery targets for the Puget Sound Management Unit are presented separately in Volume I of the Draft Recovery Plan for the Coastal-Puget Sound Distinct Population Segment of Bull Trout. The recovery targets are itemized below, and are also presented in Table 6.

Recovery targets for the Olympic Peninsula Management Unit:

1. **Maintain or expand the current distribution of bull trout in the six identified core areas.** The 10 currently identified local populations (Skokomish (2), Dungeness (2), Elwha (1), Hoh (2), Quinault (2), Queets (1)) will be used as a measure of broadly distributed spawning and rearing habitat within these core areas. In addition, spawning distribution in the two potential local populations that are essential to recovery (one in the Skokomish core area, one in the Elwha) should be restored or confirmed.

    The designation of local populations and potential local populations is based on survey data, available suitable habitat, and the professional judgement of Olympic Peninsula Recovery Team members. The recovery team acknowledges that 5 to 10 local populations in each core area may be needed to reduce risk from random naturally occurring catastrophic events (Rieman and McIntyre 1993). Furthermore, the team believes it is likely that additional local populations exist in core areas on the Olympic Peninsula. Surveys, additional population studies, and a better understanding of Olympic Peninsula bull trout fidelity to their natal streams will help identify additional local populations in this management unit.

    For recovery to occur, the distribution of these 10 local populations currently distributed throughout the 6 core areas should be maintained or expanded while abundance is increased. Reconnecting fragmented habitat and restoring degraded habitat, as well as identifying new or previously undescribed local populations, should allow the distribution of bull trout to increase as recovery progresses.

    The Olympic Peninsula Recovery Team also identified two potential local populations: Brown Creek in the Skokomish core area and Little River in the Elwha core area. Bull trout have been documented in these drainages, and habitat is considered adequate to support a local population once it is restored. These streams do not have adequate survey data and should be investigated to determine whether local populations (*i.e.* spawning and rearing) are currently present. The two potential local

Table 6. Summary of the recovery targets for bull trout in the Olympic Peninsula Management Unit.

Core Areas	**Number of Local and Potential Local Populations[1]**	**Core Area Minimum Adult Abundance**	**Trend in Abundance**	**Current Number of Known and Suspected Barriers to be Addressed**
Skokomish	2 local populations 1 potential	700	stable to increasing	at least 2
Dungeness	2 local populations	1,000	stable to increasing	at least 1
Elwha	1 local populations 1 potential	1,000	stable to increasing	at least 2
Hoh	2 local populations	1,000	stable to increasing	at least 1
Quinault	2 local populations	1,000	stable to increasing	at least 1
Queets	1 local population	1,000	stable to increasing	
Total	10 local populations 2 potential	5,700	stable to increasing	at least 7[2]

[1] Local population numbers and estimated adult abundance were determined by the Olympic Peninsula Bull Trout Recovery Team (Olympic Peninsula Recovery Team, *in litt.* 2001). These numbers may be revised when more information is available. For core areas where specific information is lacking, a local population may be represented by a single headwater tributary or complex of tributaries. Further genetic studies are needed to more accurately delineate local populations, quantify spawning-site fidelity, and straying rates. Increased survey effort may identify additional local populations within the management unit (Recovery Action 5.5.2).

[2] This number is based on known major barriers to bull trout movement. There are likely more barriers to bull trout movement that have not yet been identified (*i.e.*, specific culverts) that will be added to this list following completion of surveys and inventories.

populations were determined to be essential to bull trout recovery as they would help attain recovery objectives and management unit targets for distribution and abundance and improve connectivity within core areas.

2. **Achieve minimum estimated abundance of at least 5,700 adult spawners in the Olympic Peninsula Management Unit, including at least 1,000 spawning adults in each of the Dungeness, Elwha, Hoh, Queets, and Quinault core areas and at least 700 spawning adults in the Skokomish core area**. Estimates of the recovered abundance for bull trout in this management unit are based on a recommended minimum abundance of 1,000 adult spawners to reduce the likelihood of genetic drift (Rieman and Allendorf 2001) and the professional judgement of the recovery team. Estimates also included consideration of surveyed fish densities, habitats, and potential fish production after threats have been addressed. The recovery team acknowledges that the recommended abundance level of 1,000 spawning adults is based mainly on genetic considerations and may not account for other variables, such as population structure, necessary for the long-term persistence of viable populations. The recovered abundance level in the Skokomish core area will be limited by available habitat and is estimated to be 700 adult spawners when the core area reaches its recovered potential.

With the collection of more clearly documented population data, the numbers required for recovered abundance may be refined in the recovery target levels for each of the core areas. Abundance is expected to increase as recovery efforts provide for the expansion of spawning and juvenile rearing areas and the restoration of important migratory corridors. The recovered abundance estimates are based on the recovery team's estimates of restored productive capacities of identified and potential local populations.

3. **Restore adult bull trout to exhibit stable or increasing trends in abundance at or above the recovered abundance level within the core areas in the Olympic Peninsula Management Unit based on 10 to 15 years (representing at least two bull trout generations) of monitoring data. (Note: generation time varies with demographic variables such**

as age at maturity, fecundity, frequency of spawning, and longevity, but typically falls in the range of 5 to 8 years for a single bull trout generation). Bull trout in core areas that are presently below their recovered abundance level will exhibit increasing trends**,** whereas bull trout in core areas that may already be at their recovered abundance level will exhibit stable trends. Because there is so little baseline information about bull trout productivity in the Olympic Peninsula Management Unit, the recovery team believes that it will require at least 15 years of monitoring to accurately determine a stable or increasing trend.

4. **Restore connectivity by identifying and addressing specific existing and potential barriers to bull trout movement in the Olympic Peninsula Management Unit**. Connectivity criteria will be met when intact migratory corridors are present among all local populations within each core area, thus providing opportunity for genetic exchange and life history diversity. Several man-made barriers to bull trout migration exist within the management unit, and this recovery plan recommends actions to identify, assess, and reduce barriers to bull trout passage. Although achieving criteria 1 through 3 is expected to depend on providing passage at barriers (including barriers due to physical obstructions, unsuitable habitat, and water quality) throughout all core areas in the management unit, the intent of this criterion is to note specific barriers to address, or actions that must be performed to achieve recovery. Activities necessary to fulfill this criterion include addressing specific barriers to bull trout migration (Recovery Action 1.2.4) at Cushman Dams 1 and 2 (Skokomish core area); Elwha Dam and Glines Canyon Dam (Elwha core area); the Washington Department of Fish and Wildlife Dungeness Fish Hatchery (Dungeness core area); and the U.S. Fish and Wildlife Service Quinault National Fish Hatchery (Quinault core area).

The development of criteria and specific actions necessary for remaining connectivity needs will be implemented as the necessary information becomes available. Actions that will be needed following identification and assessment of specific problem areas include eliminating entrainment in diversions (Recovery Action 1.2.1), providing fish passage at diversions (Recovery Action 1.2.2), eliminating culvert barriers (Recovery Action 1.2.3), and improving instream flows (Recovery Action 1.2.5). Substantial gains in reconnecting fragmented habitat may be achieved in the Skokomish, Dungeness, Queets, Quinault, and Hoh core areas by restoring passage over or around many of the barriers that are typically located on smaller streams, including road crossings, culverts, and water diversions.

The known barriers are listed above and in the Recovery Measures Narrative section of this plan, but many (*e.g.*, culverts) have not yet been identified or have not yet been addressed. However, they are collectively important to recovery. Actions to identify and assess barriers to bull trout passage are recommended in this recovery plan and appropriate actions must be implemented. A list of all such artificial barriers should be prepared in the first 5 years of implementation, and prioritized so that highest priority is directed towards providing access to potential spawning and rearing habitat in local populations, followed by providing access to additional foraging habitats. Substantial progress must be made in providing passage at a significant number of these sites to meet the bull trout recovery targets for connectivity.

Recovery targets for the Olympic Peninsula Management Unit were established to assess whether recovery actions are resulting in the recovery of bull trout. The Olympic Peninsula Recovery Team expects that the recovery process will be dynamic and will be refined as more information becomes available.

Research Needs

Based on the best scientific information available, the Olympic Peninsula Recovery Team has identified recovery targets and actions necessary for recovery of bull trout within the management unit. However, the recovery team recognizes that uncertainties exist regarding bull trout population abundance, distribution, and actions needed to achieve recovery. The recovery team believes that if effective management and recovery are to occur, the recovery plan for the Olympic Peninsula should be viewed as a “living” document that will be updated as new information becomes available. The recovery team will rely on adaptive management to guide recovery implementation. Adaptive management is a continuing process of planning, monitoring, evaluating management actions, and research. Adaptive management will involve a broad spectrum of user groups and will lay the framework for decision making relative to recovery implementation, and ultimately the possible revision of recovery targets in this management unit. As a part of this adaptive management approach, the recovery team has identified research needs that are essential within the management unit. The research needs are listed by priority and, where applicable, in order of sequence.

Impacts of Recreational and Tribal Fisheries on Bull Trout. Additional information is needed regarding the extent of incidental mortality of bull trout in State recreational fisheries and Tribal fisheries. These fisheries tend to impact the largest fish, and core areas with popular recreational fisheries or important Tribal salmon fisheries may be experiencing significant incidental bull trout mortalities. Bull trout mortalities related to Tribal net fishery and/or recreational angling have been documented in the Skokomish and Hoh core areas (Ereth, *in litt.* 2003; Brenkman and Corbett, Olympic National Park, *in litt.* 2003a).

Monitoring of both fishing effort and catch is needed from a representative sample of rivers throughout the management unit area. Better estimates of bull trout catches are also needed throughout the year. Catch rates for bull trout may be highest during the summer months, but there is substantially more fishing effort on these rivers during the fall and winter salmon and steelhead fisheries.

It is unclear whether there is an impact by recreational anglers on bull trout spawning or staging. Many spawning areas are assumed to be high in Olympic Peninsula watersheds, and access may be difficult during the late fall and winter when conditions are poor for hiking. Staging and spawning areas and the timing of these events should be identified to determine what impact recreational fishing could have on bull trout staging and spawning.

Additional information is needed to assess hooking and handling mortality for bull trout caught and released. While there is considerable information in the literature regarding catch-and-release mortality for trout, there is very little comparable data for char such as bull trout or Dolly Varden. Mortality rates for bull trout caught and released are needed by gear types (barbed versus barbless hooks, single versus treble hooks, and hook size), water temperatures, and bait versus artificial lures. Differences in handling stress and mortality are also needed for bull trout caught in lakes, especially those caught and released by trolling. Specific mortality rates are also needed by life stage (juveniles, prespawners, and postspawners).

Monitoring of Tribal gill-net impacts to bull trout is needed to determine the impact on bull trout populations. In addition, research is needed to develop alternative methods for salmon gill-net fisheries, such as adjusting net mesh sizes and/or duration and placement of nets, to minimize accidental capture and incidental mortality of bull trout.

Skokomish Core Area Research Needs. Since 1998, bull trout abundance trends in the North Fork Skokomish River local population during annual monitoring surveys have declined from a peak count of over 400 adults to a peak count of approximately 100 or fewer adults (WDFW 1998; S. Brenkman, pers. comm. 2003c). Bull trout abundance in the South Fork Skokomish River local population is estimated to be fewer than 100 adults. The bull trout in these two local populations represent the entire adult population in the Skokomish core area. Recent work with population characteristics and empirical models indicate smaller populations (*e.g.*, fewer than 100 spawning adults) may be prone to extirpation risk if they are isolated (Rieman and Allendorf 2001). The following are suggested research projects to provide information about the local populations in the North Fork Skokomish and South Fork Skokomish Rivers, and to more effectively identify management actions necessary for recovery of this high risk core area:

- Use genetic analyses to define the relationship of these two local populations to each other and to other core areas in the Olympic Peninsula Management Unit and to identify potential bull trout transplant[†] source(s) for either local population should this be warranted in the future.

- Implement a mark-recapture study to obtain more precise population estimates of bull trout in both local populations (Brenkman, pers. comm. 2003b).
- In the North Fork Skokomish River: (1) determine the influence of current and future hatchery planting of cutthroat trout on bull trout; and (2) determine the influence on bull trout and their prey base of fluctuating lake levels and warm waters (due to reservoir operations) at the North Fork Skokomish River inlet to the lake.
- Assess habitat in tributaries to Lake Cushman and the North Fork Skokomish River for spawning suitability; monitor to determine use by bull trout, especially as abundance increases.
- Determine extent of the threat of hybridization of bull trout with brook trout in the South Fork Skokomish River.
- Use creel surveys or other methods to determine incidental catch and mortality of bull trout during the trout and salmon fisheries.

Distribution, Abundance, and Productivity in Core Areas. Identifying additional spawning and rearing locations for all core areas will be the first step in developing a monitoring and assessment program. Little is known about bull trout spawning and juvenile rearing sites within the Olympic Peninsula core areas. Additional baseline information needed for a monitoring and assessment program include migration timing, freshwater tributary residence time, frequency of spawning, prey consumption, mortality rates and causes, life history types, abundance estimates, and others. The development and application of models that assess extinction risk relative to abundance and distribution parameters are critical in refining recovery targets as the recovery process proceeds.

Locating bull trout spawning and juvenile rearing areas has been problematic on the Olympic Peninsula. Adult and juvenile bull trout are difficult to survey. Redd surveys are subject to temporal variability and observer error. Although Olympic National Park, Olympic National Forest, and the Washington Department of Fish and Wildlife have made extensive efforts to locate bull trout spawning sites on the Olympic Peninsula, difficult access, poor water visibility, and the concurrent presence of other spawning salmonids (coho and Chinook salmon) have further confounded efforts to locate additional sites and local populations. The development of a predictive model of suitable habitat used by juvenile and resident bull trout would help to more precisely define the area for surveys intended to detect new spawning or juvenile rearing sites. A suitable habitat model would also help prioritize areas for recovery efforts.

Bull trout spawning-site locations are related to the presence of adequate coldwater temperatures and often to areas with groundwater upwellings. Juvenile rearing is also limited by suitable water temperature regimes. The development of a model or protocol for determining potential surface water temperatures and groundwater exchange areas would be useful for locating spawning areas and for prioritizing areas for recovery efforts.

Representative spawning index reaches or other appropriate surrogates must be developed as a priority for all core areas to adequately monitor changes in adult abundance. Index reaches have only been established in the Skokomish and Hoh core areas.

Use of the lower watersheds on the Olympic Peninsula by bull trout for foraging, overwintering, and potentially for thermal refugia is poorly understood. Understanding the spatial and temporal use of lower river and tributary systems that are important for bull trout foraging and summer thermal refugia has been identified as a research need.

Marine, Estuarine, and Coastal River Use by Anadromous Bull Trout. Bull trout's complete use of these marine and estuarine waters, including habitat preferences (depth, salinity, substrate, etc.), range of migration, and foraging requirements, is poorly understood. A better understanding of migration patterns and foraging opportunities in the coastal river, nearshore, and estuarine habitat would enhance the identification of recovery opportunities and actions needed. Our current understanding of bull trout estuarine and marine use is based on limited observational data, ongoing research projects, and inferences drawn from work conducted on similar species outside the management unit (*e.g.* Dolly Varden). To adequately protect, conserve, and restore estuarine and marine habitats that can support bull trout, research is needed to determine the species' full range of habitat preferences (*e.g.*, depth, salinity, bottom types, foraging habitats). Available information indicates bull trout use primarily nearshore waters, however, this use may be biased due to the limitations of sampling in deeper, more offshore locations. Based on a limited amount of diet analysis, we do know that in addition to juvenile salmonids, a number of small marine forage fish species are critical to bull trout in estuarine and marine waters (*i.e.*, surf smelt, sandlance, Pacific herring) (WDFW *et al*. 1997), making the protection of key forage fish habitats critical to the recovery of bull trout. It is critical to determine if there are other species, such as specific invertebrates or other estuarine and marine fish, that are also important forage items either in certain feeding areas or to particular bull trout life stages. It is also important to better understand the relationship between these essential prey resources and the habitats which support their production and distribution. The processes which build and sustain nearshore habitats are highly susceptible to human impacts, such as bulkheads and other shoreline armoring, which separate beaches from the bluffs which feed them. The protection of key forage fish habitats is essential to recovery of anadromous bull trout.

Currently, a portion of the migratory bull trout on the Olympic Peninsula appear to migrate into the Strait of San Juan de Fuca, the Pacific Ocean, and Grays Harbor to overwinter and feed, either within those areas or in adjacent coastal rivers and streams. Historically, bull trout also migrated into Hood Canal to overwinter and feed. The preliminary results of acoustic telemetry work in the Puget Sound (F. Goetz, pers. comm. 2002b) and the Hoh River (Brenkman and Corbett *in litt.* 2003a,b) indicate that bull trout from more than one river intermingle in nearshore marine and estuarine waters. The recovery team believes that coastal river, marine, and nearshore foraging and migration studies for the Olympic Peninsula Management Unit should be coordinated with the Puget Sound Management Unit to provide a more complete understanding of anadromous bull trout habitat requirements. Hood Canal westside tributary rivers (Duckabush, Dosewallips, Hamma Hamma, etc.), and the Hoquiam River have been identified as areas with research needs to determine if and how they may be used by bull trout.

Population Structure Within Core Areas. The Olympic Peninsula Recovery Team recommends genetics studies to more precisely describe bull trout population structure in each core area. This information is essential for developing a more comprehensive understanding of bull trout interactions and population dynamics within the management unit. Additional information on population structure would greatly assist in further refining or revising (confirming, splitting, or combining) the currently identified local populations and, potentially, the core areas themselves. A genetics study plan and a comprehensive and coordinated sampling effort within all identified local populations are necessary for acquiring this information.

Key Habitat Features Requiring Protection, Restoration and Enhancement. Additional research is needed to identify key habitat features and limiting factors with greater precision for bull trout in both freshwater and marine habitats to ensure that habitat protection, restoration, and enhancement activities address critical limiting factors. Priorities include identification of key groundwater sources, hyporheic areas[†], and other cold water refugia; better information on the rates and locations of exposure to and sublethal effects of various environmental contaminants; identification of required water temperature regimes in river reaches used for foraging and migration; and identification of key habitat features in migratory corridors and overwintering areas.

Monitoring and Assessment Program. This draft recovery plan is the first step in the planning process for bull trout recovery in the Olympic Peninsula Management Unit. The recovery team identified the need to develop a standardized monitoring and assessment program to more accurately describe the current status of bull trout within the management unit, as well as to identify sampling protocols to allow monitoring of recovery action effectiveness. We will take the lead in developing a comprehensive monitoring approach that will provide guidance and consistency in evaluating bull trout populations. Evaluating implementation and monitoring effectiveness of recommended actions will be an important component in the application of adaptive management in recovery implementation. Monitoring and evaluation of population levels and distribution will be an important component of any adaptive management approach.

Potential Use of Satsop River. The Satsop River is on the southern coastal margin of the species' range, and any bull trout in this region are likely the last remnants of their distribution in the Chehalis River watershed. Currently no core area exists for the entire Chehalis River basin. Water temperatures in the upper West Fork Satsop River and Canyon River are suitable for bull trout spawning and rearing (L. Ogg, pers. comm. 2003c). The Olympic Peninsula

Recovery Team believes that, with restoration, the Satsop River provides the highest likelihood of establishing a functioning core area within the Chehalis River basin. Bull trout in the Satsop River would be important in maintaining the full genetic diversity and evolutionary potential of the species. Although passive recolonization would likely take a long time, the recovery team believes that using hatcheries or supplementing populations are not needed and should not be considered for this management unit at this time.

Little is known about bull trout distribution in, and use of, the Chehalis River basin. Historically, large numbers of bull trout were found in the upper West Fork Satsop and Canyon Rivers (J. Webster, pers. comm. 2001). Surveys conducted by the Olympic National Forest in the West Fork Satsop River since 1997 have not detected bull trout in the system (L. Ogg, pers. comm. 2003b). However, bull trout have been recently observed in Grays Harbor (Jeanes *et al.* 2003). Although the Washington Department of Fish and Wildlife reported a single juvenile char in 1997 (WDFW 1998), they now believe it likely escaped from a fish farm (J. Uehara, WDFW, *in litt.* 2002). Other rivers draining to either Grays Harbor or the Chehalis River that have recently documented bull trout include the Wishkah and Humptulips Rivers (N. Dachtler, *in litt.*; 2001; M. Ereth, *in litt.* 2002).

The West Satsop Watershed Analysis described fish habitat in the West Fork Satsop River as degraded (Weyerhauser and Simpson Timber Company 1995). Extensive road building and forest management resulting in reductions in pool frequency, reduction of in-channel large wood and large wood recruitment, elevated temperatures, gravel scour, and increased fine sediment inputs were cited as reasons for the “degraded” designation.

Minimum criteria to support local populations of local bull trout populations include adequate stream size, gradient, flow, groundwater contributions, temperature, pools and spawning substrate, and riparian cover. A determination of habitat adequacy within the West Fork Satsop River to meet these minimum criteria will require a stream inventory and analysis (feasibility study).